US012121478B2

(12) **United States Patent**
Augustine et al.

(10) **Patent No.: US 12,121,478 B2**
(45) **Date of Patent: *Oct. 22, 2024**

(54) **RELOCATION MODULE AND METHODS FOR SURGICAL EQUIPMENT**

(71) Applicant: **Augustine Biomedical + Design, LLC**, Eden Prairie, MN (US)

(72) Inventors: **Scott D. Augustine**, Deephaven, MN (US); **Susan D. Augustine**, Deephaven, MN (US); **Garrett J. Augustine**, Deephaven, MN (US); **Brent M. Augustine**, Savage, MN (US); **Ryan S Augustine**, Minneapolis, MN (US); **Randall C. Arnold**, Minnetonka, MN (US)

(73) Assignee: **Augustine Biomedical + Design, LLC**, Eden Prairie, MN (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **18/218,344**

(22) Filed: **Jul. 5, 2023**

(65) **Prior Publication Data**

US 2023/0346622 A1 Nov. 2, 2023

Related U.S. Application Data

(63) Continuation of application No. 18/136,141, filed on Apr. 18, 2023, now Pat. No. 11,752,056, which is a

(Continued)

(51) **Int. Cl.**

A61G 13/10 (2006.01)
A61B 50/13 (2016.01)

(Continued)

(52) **U.S. Cl.**

CPC ***A61G 13/108*** (2013.01); ***A61B 50/13*** (2016.02); ***A61B 50/15*** (2016.02); ***A61M 16/06*** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC A61G 13/108; A61M 16/06; A61M 16/18; A61M 16/01; A61B 50/13; A61B 50/15;

(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,105,028	A	8/1978	Sadlier et al.
4,531,956	A	7/1985	Howorth

(Continued)

FOREIGN PATENT DOCUMENTS

CN	101980732	A	2/2011
EP	3103385	A1	12/2016

(Continued)

OTHER PUBLICATIONS

"U.S. Appl. No. 18/099,074, Notice of Allowance dated Aug. 7, 2023", 8 pgs.

(Continued)

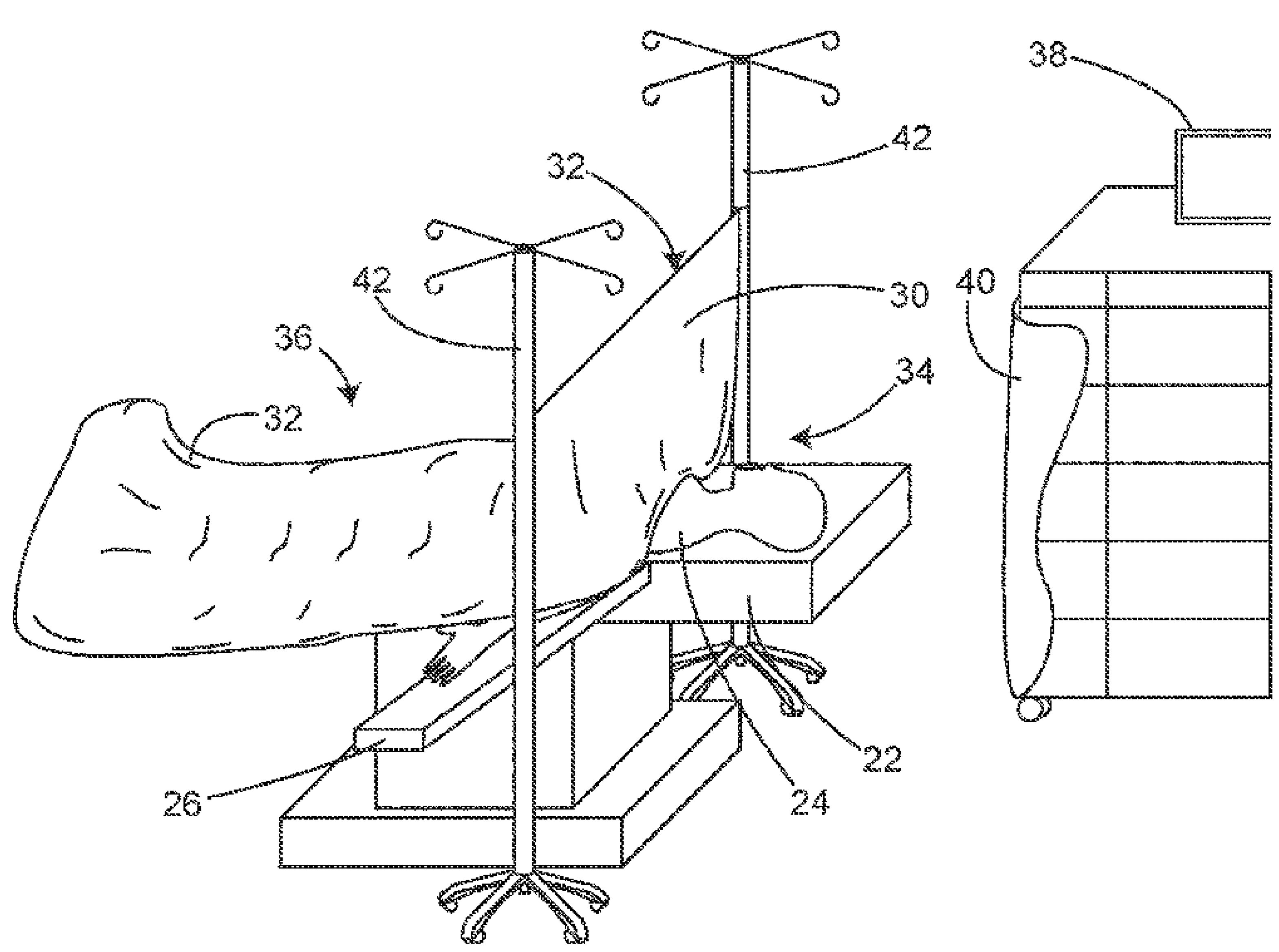
Primary Examiner — Molly Wilburn

(74) *Attorney, Agent, or Firm* — Schwegman Lundberg & Woessner, P.A.

(57) **ABSTRACT**

An anesthetic equipment storage and waste air management module configured to housing electronic and electromechanical surgical equipment including a system to measure and record administration of one or more IV medications or fluids for IV administration. The module can include a housing having a lower section and a tower-like upper section, wherein the lower section is configured to house unrelated waste heat-producing electronic and electromechanical surgical equipment. The module can also include a cowling that substantially confines waste heat generated by the unrelated waste heat-producing electronic and electromechanical surgical equipment, and can include a system for measuring and recording the administration of the one or more IV medications and fluids.

27 Claims, 57 Drawing Sheets



Related U.S. Application Data

continuation of application No. 18/099,475, filed on Jan. 20, 2023, now Pat. No. 11,666,500, which is a continuation of application No. 17/875,055, filed on Jul. 27, 2022, now Pat. No. 11,583,461, which is a continuation of application No. 17/697,398, filed on Mar. 17, 2022, now Pat. No. 11,523,960, which is a continuation of application No. 17/375,546, filed on Jul. 14, 2021, now Pat. No. 11,291,602, which is a continuation of application No. 17/199,722, filed on Mar. 12, 2021, now Pat. No. 11,173,089, which is a continuation of application No. 17/092,681, filed on Nov. 9, 2020, now Pat. No. 10,993,865, which is a continuation of application No. 16/879,406, filed on May 20, 2020, now Pat. No. 10,869,800, which is a continuation-in-part of application No. 16/601,924, filed on Oct. 15, 2019, now Pat. No. 10,702,436, which is a continuation of application No. 16/593,033, filed on Oct. 4, 2019, now Pat. No. 10,653,577, which is a continuation of application No. 16/364,884, filed on Mar. 26, 2019, now Pat. No. 10,507,153, which is a continuation-in-part of application No. 15/935,524, filed on Mar. 26, 2018, now Pat. No. 10,512,191.

(60) Provisional application No. 62/782,901, filed on Dec. 20, 2018.

(51) **Int. Cl.**

A61B 50/15	(2016.01)
A61B 90/50	(2016.01)
A61M 16/06	(2006.01)
A61M 16/18	(2006.01)
A61B 46/10	(2016.01)
A61M 16/01	(2006.01)
B01D 46/00	(2022.01)

(52) **U.S. Cl.**
CPC ***A61M 16/18*** (2013.01); *A61B 46/10* (2016.02); *A61B 2050/155* (2016.02); *A61B 90/50* (2016.02); *A61M 16/01* (2013.01); *B01D 46/0093* (2013.01)

(58) **Field of Classification Search**
CPC ... A61B 46/10; A61B 90/50; A61B 2050/155; B01D 46/0093
USPC 55/385.1, 385.2, 385.4, 467, 473, 485, 55/410, 356; 96/134, 146; 604/319, 322, 604/902
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,967,320	A	10/1990	Paschal	
5,000,737	A	3/1991	Free et al.	
5,399,007	A	3/1995	Marconet	
5,409,511	A	4/1995	Paul	
5,516,313	A	5/1996	Lumpkin	
5,626,140	A	5/1997	Feldman	
5,655,905	A	8/1997	Jaimes et al.	
5,695,536	A	12/1997	Fabrizi	
7,494,536	B2	2/2009	Kang et al.	
7,597,731	B2	10/2009	Palmerton et al.	
7,674,436	B1	3/2010	Feldman et al.	
7,753,977	B2	7/2010	Lyons et al.	
9,603,956	B2	3/2017	Newham	
10,312,191	B2	6/2019	Jung et al.	
10,507,153	B2 *	12/2019	Augustine	A61M 16/18
10,512,191	B2 *	12/2019	Augustine	H05K 5/0213
10,638,638	B2	4/2020	Augustine et al.	
10,652,577	B2	5/2020	Thoreau et al.	
10,653,577	B2 *	5/2020	Augustine	A61B 50/15
10,702,436	B2 *	7/2020	Augustine	A61M 1/777
10,869,800	B2 *	12/2020	Augustine	A61M 16/18
10,888,482	B2	1/2021	Augustine et al.	
10,993,865	B2 *	5/2021	Augustine	A61B 50/15
10,993,885	B1	5/2021	Fernandez	
11,035,377	B2	6/2021	Niwa et al.	
11,045,377	B2	6/2021	Augustine et al.	
11,160,710	B1	11/2021	Augustine et al.	
11,173,089	B2 *	11/2021	Augustine	A61G 13/108
11,219,569	B2	1/2022	Augustine et al.	
11,219,570	B2	1/2022	Augustine et al.	
11,285,065	B2	3/2022	Augustine et al.	
11,291,602	B2 *	4/2022	Augustine	A61B 46/20
11,426,318	B2	8/2022	Augustine et al.	
11,426,319	B2	8/2022	Augustine et al.	
11,426,320	B2	8/2022	Augustine et al.	
11,432,982	B2	9/2022	Augustine et al.	
11,432,983	B2	9/2022	Augustine et al.	
11,446,196	B2	9/2022	Augustine et al.	
11,523,960	B2 *	12/2022	Augustine	A61M 16/06
11,564,856	B2	1/2023	Augustine et al.	
11,583,459	B2	2/2023	Augustine et al.	
11,583,460	B2	2/2023	Augustine et al.	
11,583,461	B2 *	2/2023	Augustine	A61B 46/20
11,583,998	B2	2/2023	Moon	
11,642,270	B2	5/2023	Augustine et al.	
11,648,166	B2	5/2023	Augustine et al.	
11,654,070	B2	5/2023	Augustine et al.	
11,666,500	B1	6/2023	Augustine et al.	
11,679,052	B2	6/2023	Augustine et al.	
11,701,282	B2	7/2023	Augustine et al.	
11,766,372	B2	9/2023	Augustine et al.	
11,766,373	B2	9/2023	Augustine et al.	
2001/0035702	A1	11/2001	Murphy et al.	
2002/0074403	A1	6/2002	Krichever et al.	
2002/0120211	A1	8/2002	Wardle et al.	
2002/0183599	A1	12/2002	Castellanos	
2003/0033790	A1	2/2003	Hague	
2003/0141687	A1	7/2003	Wixted et al.	
2003/0150328	A1	8/2003	Hansson et al.	
2004/0103789	A1	6/2004	Lan et al.	
2004/0176984	A1	9/2004	White et al.	
2004/0247016	A1	12/2004	Faries et al.	
2004/0249673	A1	12/2004	Smith	
2004/0262146	A1	12/2004	Platt et al.	
2005/0016982	A1	1/2005	Campf et al.	
2005/0060974	A1	3/2005	Palmerton et al.	
2005/0087256	A1	4/2005	Clark	
2005/0097870	A1	5/2005	Moshenrose	
2005/0261551	A1	11/2005	Couvillon	
2006/0030820	A1	2/2006	Alheidt et al.	
2006/0042205	A1	3/2006	Kalous et al.	
2006/0144942	A1 *	7/2006	Evans	A61M 5/31533 604/189
2006/0163829	A1	7/2006	Livengood et al.	
2006/0229506	A1	10/2006	Castellanos	
2007/0199287	A1	8/2007	Wiser	
2007/0225690	A1	9/2007	Sekiguchi et al.	
2007/0253596	A1	11/2007	Murata et al.	
2007/0260487	A1	11/2007	Bartfeld et al.	
2008/0097315	A1	4/2008	Miner et al.	
2008/0173178	A1	7/2008	Metteer	
2008/0314978	A1	12/2008	Fedorko et al.	
2009/0141947	A1	6/2009	Kyyko et al.	
2009/0188311	A1	7/2009	Cadieux et al.	
2010/0094262	A1	4/2010	Tripathi et al.	
2010/0172550	A1	7/2010	Gilley et al.	
2010/0191541	A1	7/2010	Prokoski	
2010/0324380	A1	12/2010	Perkins et al.	
2010/0324936	A1	12/2010	Vishnubhatla et al.	
2011/0030560	A1	2/2011	Bohlen et al.	
2011/0054310	A1	3/2011	Taylor et al.	
2011/0196304	A1	8/2011	Kramer et al.	
2011/0264136	A1	10/2011	Choi et al.	
2011/0305376	A1	12/2011	Neff	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2011/0317004 A1 12/2011 Tao
2012/0022443 A1 1/2012 Robertson et al.
2012/0024154 A1 2/2012 Augustine et al.
2012/0026308 A1 2/2012 Johnson et al.
2012/0154120 A1 6/2012 Alloro et al.
2012/0154582 A1* 6/2012 Johnson G06Q 10/00 340/521
2012/0177256 A1 7/2012 Keefe et al.
2012/0305787 A1 12/2012 Henson
2013/0041258 A1 2/2013 Patrick et al.
2013/0243647 A1 9/2013 Garner et al.
2013/0269714 A1 10/2013 Roe et al.
2013/0277430 A1 10/2013 Zumsteg et al.
2014/0081175 A1 3/2014 Telfort
2014/0194793 A1 7/2014 Nakata et al.
2014/0262553 A1 9/2014 Pollock et al.
2015/0168207 A1 6/2015 Pollock et al.
2015/0209510 A1 7/2015 Burkholz et al.
2015/0220080 A1 8/2015 Nixon et al.
2015/0223890 A1 8/2015 Miller et al.
2015/0224237 A1 8/2015 Reasoner et al.
2015/0363566 A1 12/2015 Johnson et al.
2016/0001213 A1 1/2016 Balcik
2016/0042623 A1* 2/2016 Riley G16H 40/67 340/573.1
2016/0085922 A1 3/2016 Sweeney
2016/0103967 A1 4/2016 Bulut et al.
2016/0119593 A1 4/2016 Schultz et al.
2016/0125137 A1 5/2016 Ott
2016/0188831 A1 6/2016 Kurtz et al.
2016/0225144 A1 8/2016 Spahn et al.
2016/0247277 A1 8/2016 Kriheli et al.
2016/0283691 A1 9/2016 Ali
2016/0362234 A1 12/2016 Peret et al.
2016/0379504 A1 12/2016 Bailey et al.
2017/0039227 A1 2/2017 Herbst et al.
2017/0095170 A1 4/2017 Verkruijsse et al.
2017/0112954 A1 4/2017 Dayton
2017/0140125 A1 5/2017 Hogg et al.
2017/0142933 A1 5/2017 Neskin et al.
2017/0147787 A1 5/2017 Albrecht et al.
2017/0156661 A1 6/2017 Hughes et al.
2017/0173262 A1* 6/2017 Veltz G16H 20/17
2017/0185717 A1 6/2017 Williams et al.
2017/0209658 A1 7/2017 Tobia et al.
2017/0235913 A1 8/2017 Aly et al.
2017/0238842 A1 8/2017 Jacquel et al.
2017/0251990 A1 9/2017 Kheradpir et al.
2017/0262614 A1 9/2017 Vishnubhatla et al.
2017/0300385 A1 10/2017 Huang
2017/0326385 A1 11/2017 Fishman
2017/0333626 A1 11/2017 Mansour
2017/0337493 A1 11/2017 Paramasivan et al.
2018/0036583 A1 2/2018 Lagree et al.
2018/0067484 A1 3/2018 Troy et al.
2018/0132966 A1 5/2018 Desaulniers et al.
2018/0169327 A1 6/2018 Iddon et al.
2018/0182475 A1 6/2018 Cossler et al.
2018/0225346 A1 8/2018 Liu et al.
2018/0303574 A1 10/2018 Ramirez Luna et al.
2018/0353698 A1 12/2018 Saint et al.
2018/0365385 A1 12/2018 Cooney et al.
2019/0057760 A1* 2/2019 Schwartz G06N 3/04
2019/0105120 A1 4/2019 Norman et al.
2019/0183591 A1* 6/2019 Johnson G06F 3/04845
2019/0197466 A1 6/2019 Hand, III et al.
2019/0201126 A1* 7/2019 Shelton, IV G16H 20/40
2019/0201158 A1* 7/2019 Shelton, IV A61B 90/361
2019/0290524 A1 9/2019 Augustine et al.
2019/0294965 A1 9/2019 Buhrmann et al.
2019/0297745 A1 9/2019 Augustine et al.
2019/0328598 A1 10/2019 Mangiardi
2019/0333621 A1* 10/2019 Bengtsson A61B 5/14532
2019/0357382 A1 11/2019 Augustine et al.
2020/0004027 A1 1/2020 Grootjans et al.
2020/0038274 A1 2/2020 Augustine et al.
2020/0046590 A1 2/2020 Augustine et al.
2020/0121496 A1 4/2020 Prokop et al.
2020/0160057 A1 5/2020 Roxas et al.
2020/0230316 A1 7/2020 Guerra et al.
2020/0268315 A1 8/2020 Burwinkel et al.
2020/0273581 A1 8/2020 Wolf et al.
2020/0281790 A1 9/2020 Augustine et al.
2020/0286610 A1 9/2020 Wartena et al.
2020/0289354 A1 9/2020 Augustine et al.
2020/0305713 A1 10/2020 Sipe et al.
2021/0052454 A1 2/2021 Augustine et al.
2021/0100710 A1 4/2021 Augustine et al.
2021/0196550 A1 7/2021 Augustine et al.
2021/0251835 A1 8/2021 Augustine et al.
2021/0316633 A1 10/2021 Kalligeros et al.
2021/0338510 A1 11/2021 Augustine et al.
2021/0338511 A1 11/2021 Augustine et al.
2021/0345954 A1 11/2021 Shelton, IV et al.
2021/0361507 A1 11/2021 Augustine et al.
2021/0361508 A1 11/2021 Augustine et al.
2021/0361509 A1 11/2021 Augustine et al.
2021/0375480 A1 12/2021 Mahon et al.
2022/0062084 A1 3/2022 Augustine et al.
2022/0071828 A1 3/2022 Augustine et al.
2022/0096305 A1 3/2022 Augustine et al.
2022/0104987 A1 4/2022 Augustine et al.
2022/0183915 A1 6/2022 Augustine et al.
2022/0202639 A1 6/2022 Augustine et al.
2022/0280085 A1* 9/2022 Retzkin A61B 5/4809
2022/0347031 A1 11/2022 Augustine et al.
2022/0354723 A1 11/2022 Augustine et al.
2022/0362085 A1 11/2022 Augustine et al.
2022/0362086 A1 11/2022 Augustine et al.
2022/0362087 A1 11/2022 Augustine et al.
2022/0362493 A1 11/2022 White
2022/0367020 A1 11/2022 Augustine et al.
2022/0370275 A1 11/2022 Augustine et al.
2023/0149236 A1 5/2023 Augustine et al.
2023/0149237 A1 5/2023 Augustine et al.
2023/0149238 A1 5/2023 Augustine et al.
2023/0149239 A1 5/2023 Augustine et al.
2023/0157918 A1 5/2023 Augustine et al.
2023/0233394 A1 7/2023 Augustine et al.
2023/0270609 A1 8/2023 Augustine et al.
2023/0270610 A1 8/2023 Augustine et al.
2023/0293374 A1 9/2023 Augustine et al.
2023/0293375 A1 9/2023 Augustine et al.
2023/0346621 A1 11/2023 Augustine et al.
2023/0346623 A1 11/2023 Augustine et al.
2023/0355457 A1 11/2023 Augustine et al.
2023/0360790 A1 11/2023 Burkholz et al.
2023/0404830 A1 12/2023 Augustine et al.
2023/0414432 A1 12/2023 Augustine et al.
2023/0414433 A1 12/2023 Augustine et al.

FOREIGN PATENT DOCUMENTS

WO 2016025989 2/2016
WO WO-2019191081 A1 10/2019
WO WO-2021236077 A1 11/2021
WO WO-2021236182 A1 11/2021
WO WO-2021236319 A1 11/2021

OTHER PUBLICATIONS

"U.S. Appl. No. 18/099,074, Response filed Jul. 13, 2023 to Non Final Office Action dated Apr. 17, 2023", 12 pgs.
"U.S. Appl. No. 18/136,141, Corrected Notice of Allowability dated Aug. 16, 2023", 2 pgs.
"U.S. Appl. No. 18/136,141, Notice of Allowance dated Jul. 11, 2023", 8 pgs.
"U.S. Appl. No. 18/142,776, Notice of Allowance dated Jul. 19, 2023", 8 pgs.
"U.S. Appl. No. 18/142,787, Non Final Office Action dated Aug. 4, 2023", 9 pgs.
"U.S. Appl. No. 18/142,787, Notice of Allowance dated Aug. 30, 2023", 9 pgs.

(56) **References Cited**

OTHER PUBLICATIONS

"U.S. Appl. No. 18/142,787, Response filed Aug. 21, 2023 to Non Final Office Action dated Aug. 4, 2023", 14 pgs.
"U.S. Appl. No. 18/191,115, Notice of Allowance dated Jul. 19, 2023", 8 pgs.
"U.S. Appl. No. 18/203,936, Non Final Office Action dated Aug. 15, 2023", 8 pgs.
"U.S. Appl. No. 18/203,936, Response filed Sep. 5, 2023 to Non Final Office Action dated Aug. 15, 2023", 12 pgs.
"U.S. Appl. No. 18/218,350, Non Final Office Action dated Aug. 21, 2023", 7 pgs.
"U.S. Appl. No. 18/218,350, Response filed Sep. 5, 2023 to Non Final Office Action dated Aug. 21, 2023", 13 pgs.
"U.S. Appl. No. 15/935,524, Corrected Notice of Allowability dated Jul. 18, 2019", 2 pgs.
"U.S. Appl. No. 15/935,524, Corrected Notice of Allowability dated Aug. 21, 2019", 2 pgs.
"U.S. Appl. No. 15/935,524, Non Final Office Action dated Mar. 8, 2019", 8 pgs.
"U.S. Appl. No. 15/935,524, Non Final Office Action dated Sep. 19, 2018", 8 pgs.
"U.S. Appl. No. 15/935,524, Notice of Allowance dated Jun. 12, 2019", 9 pgs.
"U.S. Appl. No. 15/935,524, Response filed May 15, 2019 to Non Final Office Action dated Mar. 8, 2019", 10 pgs.
"U.S. Appl. No. 15/935,524, Response filed Dec. 12, 2018 to Non Final Office Action dated Sep. 19, 2018", 18 pgs.
"U.S. Appl. No. 16/364,884, Corrected Notice of Allowability dated Aug. 29, 2019", 3 pgs.
"U.S. Appl. No. 16/364,884, Corrected Notice of Allowability dated Nov. 8, 2019", 3 pgs.
"U.S. Appl. No. 16/364,884, Non Final Office Action dated Jul. 3, 2019", 9 pgs.
"U.S. Appl. No. 16/364,884, Notice of Allowance dated Aug. 20, 2019", 10 pgs.
"U.S. Appl. No. 16/364,884, Response filed Jun. 18, 2019 to Restriction Requirement dated May 1, 2019", 9 pgs.
"U.S. Appl. No. 16/364,884, Response filed Jul. 24, 2019 to Non Final Office Action dated Jul. 3, 2019", 9 pgs.
"U.S. Appl. No. 16/364,884, Restriction Requirement dated May 1, 2019", 5 pgs.
"U.S. Appl. No. 16/519,677, Non Final Office Action dated Nov. 13, 2019", 6 pgs.
"U.S. Appl. No. 16/519,677, Response filed Dec. 17, 2019 to Non Final Office Action dated Nov. 13, 2019", 9 pgs.
"U.S. Appl. No. 16/529,283, Corrected Notice of Allowability dated Mar. 6, 2020", 2 pgs.
"U.S. Appl. No. 16/529,283, Non Final Office Action dated Sep. 18, 2019", 8 pgs.
"U.S. Appl. No. 16/529,283, Notice of Allowance dated Jan. 10, 2020", 10 pgs.
"U.S. Appl. No. 16/529,283, Response filed Dec. 13, 2019 to Non Final Office Action dated Sep. 18, 2019", 8 pgs.
"U.S. Appl. No. 16/593,033, Notice of Allowance dated Jan. 14, 2020", 10 pgs.
"U.S. Appl. No. 16/601,924, Non Final Office Action dated Dec. 5, 2019", 6 pgs.
"U.S. Appl. No. 16/601,924, Notice of Allowance dated Mar. 11, 2020", 8 pgs.
"U.S. Appl. No. 16/601,924, Response filed Feb. 26, 2020 to Non Final Office Action dated Dec. 5, 2019", 9 pgs.
"U.S. Appl. No. 16/879,406, Corrected Notice of Allowability dated Oct. 21, 2020", 2 pgs.
"U.S. Appl. No. 16/879,406, Non Final Office Action dated Jun. 9, 2020", 9 pgs.
"U.S. Appl. No. 16/879,406, Notice of Allowance dated Sep. 10, 2020", 8 pgs.
"U.S. Appl. No. 16/879,406, Response filed Sep. 2, 2020 to Non Final Office Action dated Jun. 9, 2020", 12 pgs.
"U.S. Appl. No. 16/885,715, Non Final Office Action dated Jun. 23, 2020", 9 pgs.
"U.S. Appl. No. 16/885,715, Notice of Allowance dated Sep. 22, 2020", 8 pgs.
"U.S. Appl. No. 16/885,715, Notice of Non-Compliant Amendment dated Sep. 10, 2020", 2 pgs.
"U.S. Appl. No. 16/885,715, Response filed Sep. 2, 2020 to Non Final Office Action dated Jun. 23, 2020", 12 pgs.
"U.S. Appl. No. 16/885,715, Response filed Sep. 14, 2020 to Notice of Non-Compliant Amendment dated Sep. 10, 2020", 12 pgs.
"U.S. Appl. No. 17/092,681, Non Final Office Action dated Dec. 17, 2020", 8 pgs.
"U.S. Appl. No. 17/092,681, Notice of Allowance dated Feb. 2, 2021", 9 pgs.
"U.S. Appl. No. 17/092,681, Response filed Jan. 22, 2021 to Non Final Office Action dated Dec. 17, 2020", 13 pgs.
"U.S. Appl. No. 17/103,426, Non Final Office Action dated Jan. 25, 2021", 8 pgs.
"U.S. Appl. No. 17/103,426, Notice of Allowance dated Mar. 12, 2021", 8 pgs.
"U.S. Appl. No. 17/103,426, Response filed Mar. 2, 2021 to Non Final Office Action dated Jan. 25, 2021", 9 pgs.
"U.S. Appl. No. 17/167,681, Corrected Notice of Allowability dated Sep. 21, 2021", 2 pgs.
"U.S. Appl. No. 17/167,681, Non Final Office Action dated Apr. 5, 2021", 8 pgs.
"U.S. Appl. No. 17/167,681, Notice of Allowance dated May 17, 2021", 9 pgs.
"U.S. Appl. No. 17/167,681, Notice of Allowance dated Aug. 25, 2021", 12 pgs.
"U.S. Appl. No. 17/167,681, Response filed May 5, 2021 to Non Final Office Action dated Apr. 5, 2021", 10 pgs.
"U.S. Appl. No. 17/199,722, Non Final Office dated May 12, 2021", 7 pgs.
"U.S. Appl. No. 17/199,722, Notice of Allowance dated Jul. 26, 2021", 9 pgs.
"U.S. Appl. No. 17/199,722, Preliminary Amendment filed Apr. 12, 2021", 12.
"U.S. Appl. No. 17/199,722, Response filed Jul. 14, 2021 to Non Final Office Action dated May 12, 2021", 15 pgs.
"U.S. Appl. No. 17/245,942, Corrected Notice of Allowability dated Aug. 2, 2022", 2 pgs.
"U.S. Appl. No. 17/245,942, Final Office Action dated Mar. 2, 2022", 9 pgs.
"U.S. Appl. No. 17/245,942, Non Final Office Action dated Jun. 30, 2021", 11 pgs.
"U.S. Appl. No. 17/245,942, Non Final Office Action dated Nov. 19, 2021", 13 pgs.
"U.S. Appl. No. 17/245,942, Notice of Allowance dated May 2, 2022", 10 pgs.
"U.S. Appl. No. 17/245,942, Notice of Allowance dated Jul. 27, 2021", 9 pgs.
"U.S. Appl. No. 17/245,942, Response filed Feb. 15, 2022 to Non Final Office Action dated Nov. 19, 2021", 14 pgs.
"U.S. Appl. No. 17/245,942, Response filed Apr. 15, 2022 to Final Office Action dated Mar. 2, 2022", 15 pgs.
"U.S. Appl. No. 17/245,942, Response filed Jul. 14, 2021 to Non Final Office Action dated Jun. 30, 2021", 14 pgs.
"U.S. Appl. No. 17/308,437, Non Final Office Action dated Jul. 15, 2021", 8 pgs.
"U.S. Appl. No. 17/308,437, Notice of Allowance dated Dec. 6, 2021", 9 pgs.
"U.S. Appl. No. 17/308,437, Response filed Nov. 10, 2021 to Non Final Office Action dated Jul. 15, 2021", 11 pgs.
"U.S. Appl. No. 17/332,523, Non Final Office Action dated Jul. 29, 2021", 8 pgs.
"U.S. Appl. No. 17/332,523, Notice of Allowance dated Oct. 29, 2021", 9 pgs.
"U.S. Appl. No. 17/332,523, Response filed Sep. 29, 2021 to Non Final Office Action dated Jul. 29, 2021", 13 pgs.
"U.S. Appl. No. 17/375,546, Non Final Office Action dated Oct. 27, 2021", 8 pgs.

(56) **References Cited**

OTHER PUBLICATIONS

"U.S. Appl. No. 17/375,546, Notice of Allowance dated Feb. 25, 2022", 10 pgs.
"U.S. Appl. No. 17/375,546, Response filed Jan. 27, 2022 to Non Final Office Action dated Oct. 27, 2021", 14 pgs.
"U.S. Appl. No. 17/376,469, Non Final Office Action dated Sep. 17, 2021", 9 pgs.
"U.S. Appl. No. 17/376,469, Notice of Allowance dated Nov. 23, 2021", 9 pgs.
"U.S. Appl. No. 17/376,469, Response filed Sep. 29, 2021 to Non Final Office Action dated Sep. 17, 2021", 11 pgs.
"U.S. Appl. No. 17/523,549, Corrected Notice of Allowability dated Jun. 2, 2022", 2 pgs.
"U.S. Appl. No. 17/523,549, Final Office Action dated Apr. 19, 2022", 8 pgs.
"U.S. Appl. No. 17/523,549, Non Final Office Action dated Jan. 13, 2022", 8 pgs.
"U.S. Appl. No. 17/523,549, Notice of Allowance dated May 3, 2022", 9 pgs.
"U.S. Appl. No. 17/523,549, Response filed Apr. 13, 2022 to Non Final Office Action dated Jan. 13, 2022", 12 pgs.
"U.S. Appl. No. 17/523,549, Response filed Apr. 19, 2022 to Final Office Action dated Apr. 19, 2022", 12 pgs.
"U.S. Appl. No. 17/528,832, Final Office Action dated Apr. 22, 2022", 10 pgs.
"U.S. Appl. No. 17/528,832, Non Final Office Action dated Feb. 8, 2022", 11 pgs.
"U.S. Appl. No. 17/528,832, Notice of Allowance dated Jun. 29, 2022", 10 pgs.
"U.S. Appl. No. 17/528,832, Response filed Apr. 15, 2022 to Non Final Office Action dated Feb. 8, 2022", 13 pgs.
"U.S. Appl. No. 17/528,832, Response filed Jun. 20, 2022 to Final Office Action dated Apr. 22, 2022", 13 pgs.
"U.S. Appl. No. 17/550,611, Corrected Notice of Allowability dated May 4, 2022", 2 pgs.
"U.S. Appl. No. 17/550,611, Corrected Notice of Allowability dated Jul. 15, 2022", 2 pgs.
"U.S. Appl. No. 17/550,611, Non Final Office Action dated Feb. 10, 2022", 8 pgs.
"U.S. Appl. No. 17/550,611, Notice of Allowance dated Apr. 25, 2022", 9 pgs.
"U.S. Appl. No. 17/550,611, Response filed Apr. 15, 2022 to Non Final Office Action dated Feb. 10, 2022", 13 pgs.
"U.S. Appl. No. 17/550,696, Corrected Notice of Allowability dated Aug. 8, 2022", 3 pgs.
"U.S. Appl. No. 17/550,696, Non Final Office Action dated Feb. 10, 2022", 8 pgs.
"U.S. Appl. No. 17/550,696, Notice of Allowance dated May 17, 2022", 10 pgs.
"U.S. Appl. No. 17/550,696, Response filed May 9, 2022 to Non Final Office Action dated Feb. 10, 2022", 12 pgs.
"U.S. Appl. No. 17/678,550, Final Office Action dated Jun. 3, 2022", 7 pgs.
"U.S. Appl. No. 17/678,550, Non Final Office Action dated May 13, 2022", 7 pgs.
"U.S. Appl. No. 17/678,550, Notice of Allowance dated Aug. 11, 2022", 9 pgs.
"U.S. Appl. No. 17/678,550, Preliminary Amendment filed Apr. 7, 2022", 11 pgs.
"U.S. Appl. No. 17/678,550, Response filed May 23, 2022 to Non Final Office Action dated May 13, 2022", 14 pgs.
"U.S. Appl. No. 17/678,550, Response filed Aug. 1, 2022 to Final Office Action dated Jun. 3, 2022", 14 pgs.
"U.S. Appl. No. 17/678,550, Supplementary Amendment filed Aug. 2, 2022", 13 pgs.
"U.S. Appl. No. 17/697,398, Non Final Office Action dated May 27, 2022", 7 pgs.
"U.S. Appl. No. 17/697,398, Notice of Allowance dated Aug. 19, 2022", 9 pgs.
"U.S. Appl. No. 17/697,398, Response filed Aug. 2, 2022 to Non Final Office Action dated May 27, 2022", 12 pgs.
"U.S. Appl. No. 17/862,971, Non Final Office Action dated Nov. 15, 2022", 7 pgs.
"U.S. Appl. No. 17/862,971, Notice of Allowance dated Nov. 20, 2022", 9 pgs.
"U.S. Appl. No. 17/862,971, Notice of Allowance dated Dec. 20, 2022", 9 pgs.
"U.S. Appl. No. 17/862,971, Response filed Dec. 5, 2022 to Non Final Office Action dated Nov. 15, 2022", 11 pgs.
"U.S. Appl. No. 17/873,857, Corrected Notice of Allowability dated Apr. 13, 2023", 2 pgs.
"U.S. Appl. No. 17/873,857, Non Final Office Action dated Nov. 14, 2022", 7 pgs.
"U.S. Appl. No. 17/873,857, Notice of Allowance dated Dec. 21, 2022", 9 pgs.
"U.S. Appl. No. 17/873,857, Response filed Dec. 5, 2022 to Non Final Office Action dated Nov. 14, 2022", 13 pgs.
"U.S. Appl. No. 17/873,857, Supplementary Notice of Allowability dated Mar. 14, 2023", 5 pgs.
"U.S. Appl. No. 17/873,907, Final Office Action dated Dec. 13, 2022", 7 pgs.
"U.S. Appl. No. 17/873,907, Non Final Office Action dated Nov. 14, 2022", 7 pgs.
"U.S. Appl. No. 17/873,907, Notice of Allowance dated Jan. 25, 2023", 9 pgs.
"U.S. Appl. No. 17/873,907, Response filed Dec. 5, 2022 to Non Final Office Action dated Nov. 14, 2022", 12 pgs.
"U.S. Appl. No. 17/873,907, Response filed Dec. 14, 2022 to Final Office Action dated Dec. 13, 2022", 10 pgs.
"U.S. Appl. No. 17/873,975, Non Final Office Action dated Nov. 15, 2022", 7 pgs.
"U.S. Appl. No. 17/873,975, Notice of Allowance dated Dec. 21, 2022", 9 pgs.
"U.S. Appl. No. 17/873,975, Response filed Dec. 5, 2022 to Non Final Office Action dated Nov. 15, 2022", 14 pgs.
"U.S. Appl. No. 17/874,963, Corrected Notice of Allowability dated Apr. 13, 2023", 2 pgs.
"U.S. Appl. No. 17/874,963, Non Final Office Action dated Nov. 14, 2022", 7 pgs.
"U.S. Appl. No. 17/874,963, Notice of Allowance dated Dec. 21, 2022", 9 pgs.
"U.S. Appl. No. 17/874,963, Response filed Dec. 5, 2022 to Non Final Office Action dated Nov. 14, 2022", 12 pgs.
"U.S. Appl. No. 17/874,963, Supplementary Notice of Allowability dated Mar. 14, 2023", 6 pgs.
"U.S. Appl. No. 17/874,998, Non Final Office Action dated Nov. 15, 2022", 7 pgs.
"U.S. Appl. No. 17/874,998, Notice of Allowance dated Dec. 16, 2022", 9 pgs.
"U.S. Appl. No. 17/874,998, Response filed Dec. 5, 2022 to Non Final Office Action dated Nov. 15, 2022", 13 pgs.
"U.S. Appl. No. 17/875,055, Non Final Office Action dated Nov. 15, 2022", 8 pgs.
"U.S. Appl. No. 17/875,055, Notice of Allowance dated Dec. 22, 2022", 9 pgs.
"U.S. Appl. No. 17/875,055, Response filed Dec. 5, 2022 to Non Final Office Action dated Nov. 15, 2022", 11 pgs.
"U.S. Appl. No. 18/092,532, Non Final Office Action dated Apr. 14, 2023", 7 pgs.
"U.S. Appl. No. 18/092,532, Notice of Allowance dated May 24, 2023", 8 pgs.
"U.S. Appl. No. 18/092,532, Response filed Apr. 27, 2023 to Non Final Office Action dated Apr. 14, 2023", 12 pgs.
"U.S. Appl. No. 18/099,074, Non Final Office Action dated Apr. 17, 2023", 8 pgs.
"U.S. Appl. No. 18/099,475, Corrected Notice of Allowability dated Apr. 19, 2023", 2 pgs.
"U.S. Appl. No. 18/099,475, Non Final Office Action dated Mar. 8, 2023", 7 pgs.
"U.S. Appl. No. 18/099,475, Notice of Allowance dated Apr. 4, 2023", 8 pgs.

(56) **References Cited**

OTHER PUBLICATIONS

"U.S. Appl. No. 18/099,475, Response filed Mar. 17, 2023 to Non Final Office Action dated Mar. 8, 2023", 13 pgs.
"U.S. Appl. No. 18/099,500, Notice of Allowance dated May 5, 2023", 9 pgs.
"U.S. Appl. No. 18/099,557, Corrected Notice of Allowability dated Apr. 14, 2023", 2 pgs.
"U.S. Appl. No. 18/099,557, Non Final Office Action dated Mar. 6, 2023", 7 pgs.
"U.S. Appl. No. 18/099,557, Notice of Allowance dated Apr. 5, 2023", 8 pgs.
"U.S. Appl. No. 18/099,557, Response filed Mar. 17, 2023 to Non Final Office Action dated Mar. 6, 2023", 13 pgs.
"U.S. Appl. No. 18/136,141, Non Final Office Action dated Jun. 12, 2023", 7 pgs.
"U.S. Appl. No. 18/136,141, Preliminary Amendment filed Apr. 18, 2023".
"U.S. Appl. No. 18/136,141, Response filed Jun. 28, 2023 to Non Final Office Action dated Jun. 12, 2023", 11 pgs.
"U.S. Appl. No. 18/142,776, Non Final Office Action dated Jun. 13, 2023", 7 pgs.
"U.S. Appl. No. 18/142,776, Response filed Jun. 28, 2023 to Non Final Office Action dated Jun. 13, 2023", 13 pgs.
"U.S. Appl. No. 18/191,115 Non Final Office Action dated Jun. 12, 2023", 7 pgs.
"U.S. Appl. No. 18/191,115, Response filed Jun. 28, 2023 to Non Final Office Action dated Jun. 12, 2023", 8 pgs.
"European Application Serial No. 20936131.0, Extended European Search Report dated Jun. 21, 2023", 9 pgs.
"European Application Serial No. 21807934.1, Response to Communication pursuant to Rules 161(1) and 162 EPC filed Jun. 13, 2023", 28 pgs.
"European Application No. 22206766.2, Extended European Search Report dated Mar. 22, 2023", 9 pgs.
"International Application Serial No. PCT/US2019/024054, International Preliminary Report on Patentability dated Oct. 8, 2020", 9 pgs.
"International Application Serial No. PCT/US2019/024054, International Search Report dated Jul. 25, 2019", 5 pgs.
"International Application Serial No. PCT/US2019/024054, Invitation to Pay Additional Fees mailed May 29, 2019", 3 pgs.
"International Application Serial No. PCT/US2019/024054, Written Opinion dated Jul. 25, 2019", 7 pgs.
"International Application Serial No. PCT/US2020/033804, International Preliminary Report on Patentability dated Dec. 1, 2022", 12 pgs.
"International Application Serial No. PCT/US2020/033804, International Search Report dated Aug. 28, 2020", 3 pgs.
"International Application Serial No. PCT/US2020/033804, Written Opinion dated Aug. 28, 2020", 10 pgs.
"International Application Serial No. PCT/US2021/016585, International Preliminary Report on Patentability dated Dec. 1, 2022", 15 pgs.
"International Application Serial No. PCT/US2021/016585, International Search Report dated Jun. 30, 2021", 5 pgs.
"International Application Serial No. PCT/US2021/016585, Invitation to Pay Additional Fees mailed Apr. 22, 2021", 3 pgs.
"International Application Serial No. PCT/US2021/016585, Written Opinion dated Jun. 30, 2021", 13 pgs.
"International Application Serial No. PCT/US2021/030182, International Preliminary Report on Patentability dated Dec. 1, 2022", 19 pgs.
"International Application Serial No. PCT/US2021/030182, International Search Report dated Aug. 16, 2021", 2 pgs.
"International Application Serial No. PCT/US2021/030182, Written Opinion dated Aug. 16, 2021", 17 pgs.
"U.S. Appl. No. 18/203,297, Non Final Office Action mailed Sep. 22, 2023", 8 pgs.
"U.S. Appl. No. 18/222,711, Response filed Oct. 3, 2023 to Non Final Office Action mailed Sep. 8, 2023", 8 pgs.
"U.S. Appl. No. 18/203,297, Response filed Oct. 3, 2023 to Non Final Office Action mailed Sep. 22, 2023", 11 pgs.
"U.S. Appl. No. 18/099,074, Non Final Office Action mailed Oct. 20, 2023", 90 pgs.
"U.S. Appl. No. 18/222,711, Notice of Allowance mailed Nov. 22, 2023", 8 pgs.
"U.S. Appl. No. 18/203,297, Notice of Allowance mailed Nov. 22, 2023", 9 pgs.
"U.S. Appl. No. 18/203,936, Non Final Office Action mailed Jan. 17, 2024", 42 pgs.
"U.S. Appl. No. 18/243,820, Non Final Office Action mailed Dec. 15, 2023", 8 pgs.
"U.S. Appl. No. 18/243,820, Response filed Dec. 21, 2023 to Non Final Office Action mailed Dec. 15, 2023", 10 pgs.
"European Application Serial No. 20936131.0, Response filed Jan. 10, 24 to Extended European Search Report mailed Jun. 21, 2023", 57 pgs.
Nishidate, I, et al., "Evaluation of arterial oxygen saturation using RGB camera-based remote photoplethysmography", InOptical Diagnostics and Sensing XVIII: Toward Point-of-Care Diagnostics, (Feb. 20, 2018), 208-214.
Secerbegovic, Alma, et al., "Blood pressure estimation using video plethysmography", IEEE 13th international symposium on biomedical imaging (ISBI), (2016), 4 pgs.
"U.S. Appl. No. 18/142,787, Non Final Office Action mailed Jan. 24, 2024", 23 pgs.
"U.S. Appl. No. 18/142,787, Notice of Allowance mailed Mar. 6, 2024", 11 pgs.
"U.S. Appl. No. 18/142,787, Response filed Feb. 22, 2024 to Non Final Office Action mailed Jan. 24, 2024", 15 pgs.
"U.S. Appl. No. 18/142,787, Supplemental Notice of Allowability mailed May 20, 2024", 3 pgs.
"U.S. Appl. No. 18/203,297, Non Final Office Action mailed Mar. 25, 2024", 15 pgs.
"U.S. Appl. No. 18/203,297, Response filed Mar. 5, 2024 to Restriction Requirement mailed Feb. 14, 2024", 9 pgs.
"U.S. Appl. No. 18/203,297, Restriction Requirement mailed Feb. 14, 2024", 5 pgs.
"U.S. Appl. No. 18/218,350, Non Final Office Action mailed Jan. 24, 2024", 36 pgs.
"U.S. Appl. No. 18/222,711, Non Final Office Action mailed Apr. 30, 2024", 186.
"U.S. Appl. No. 18/242,894, Non Final Office Action mailed Jan. 31, 2024", 42 pgs.
"U.S. Appl. No. 18/243,223, Non Final Office Action mailed Feb. 5, 2024", 74 pgs.
"U.S. Appl. No. 18/243,820, Non Final Office Action mailed Jan. 24, 2024", 47 pgs.
"U.S. Appl. No. 18/598,110, Restriction Requirement mailed May 2, 2024", 6 pgs.
"European Application Serial No. 21808856.5, Response filed Mar. 4, 2024 to Extended European Search Report mailed Sep. 18, 2023", 24 pgs.
Sharidan, Parr K, et al., "Automated mapping of laboratory tests to LOINC codes using noisy labels in a national electronic health record system database", Journal of the American Medical Informatics Association 25, (2018), 1292-1300.

* cited by examiner

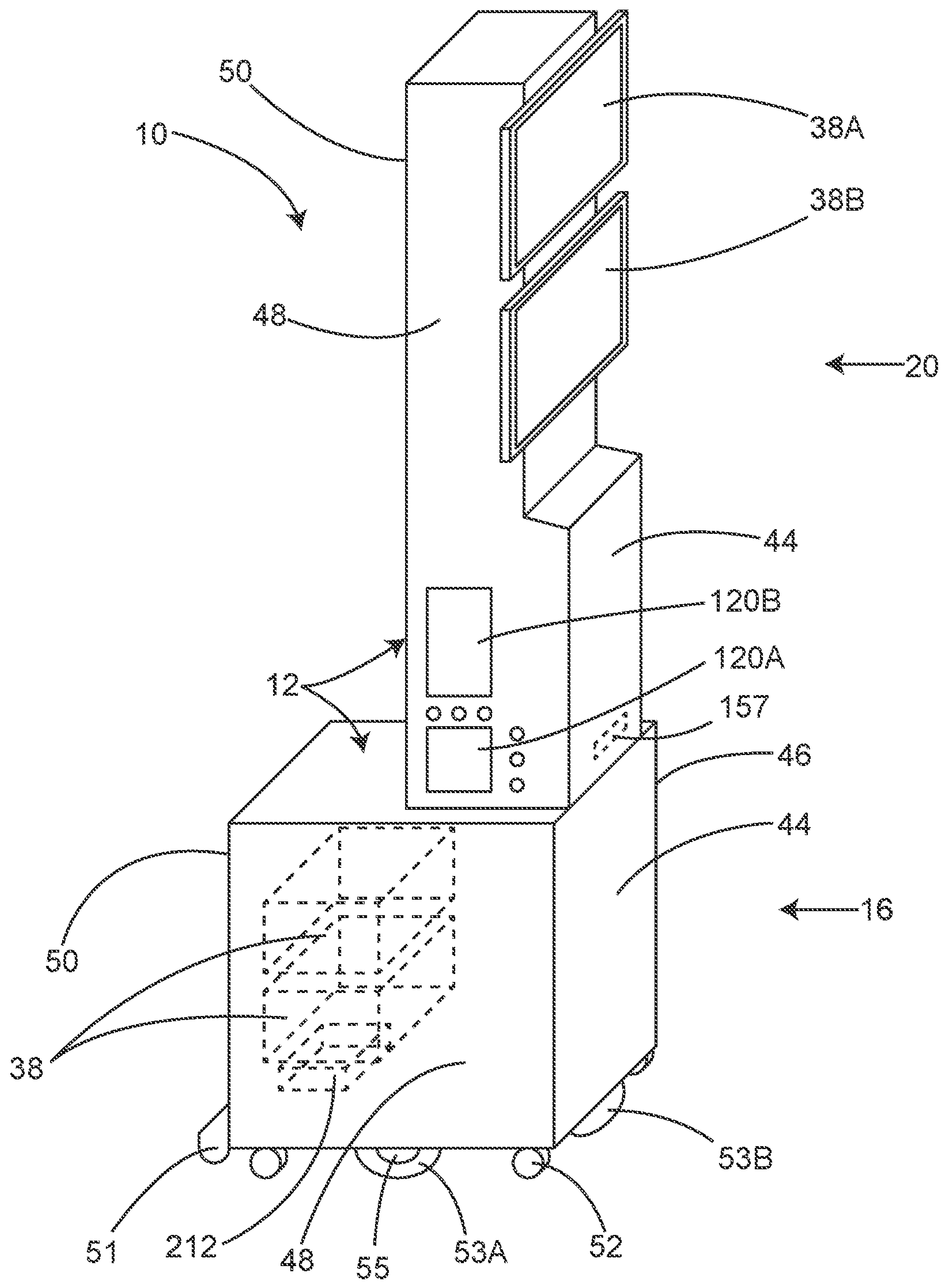

50
10
38A
38B
48
20
44
120B
120A
12
157
46
44
16
50
38
51
212
48
55
53A
52
53B

Fig. 1

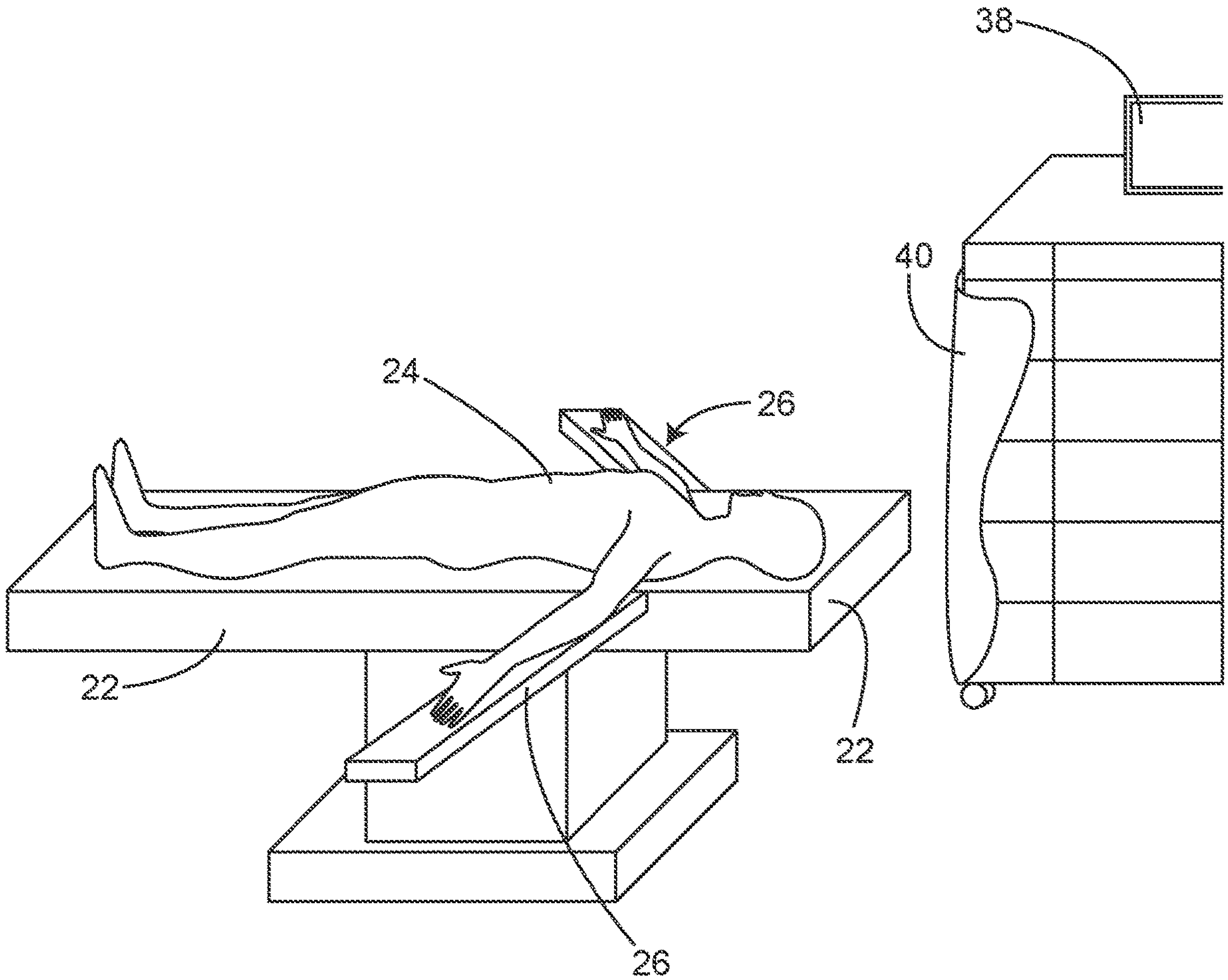


Fig 2

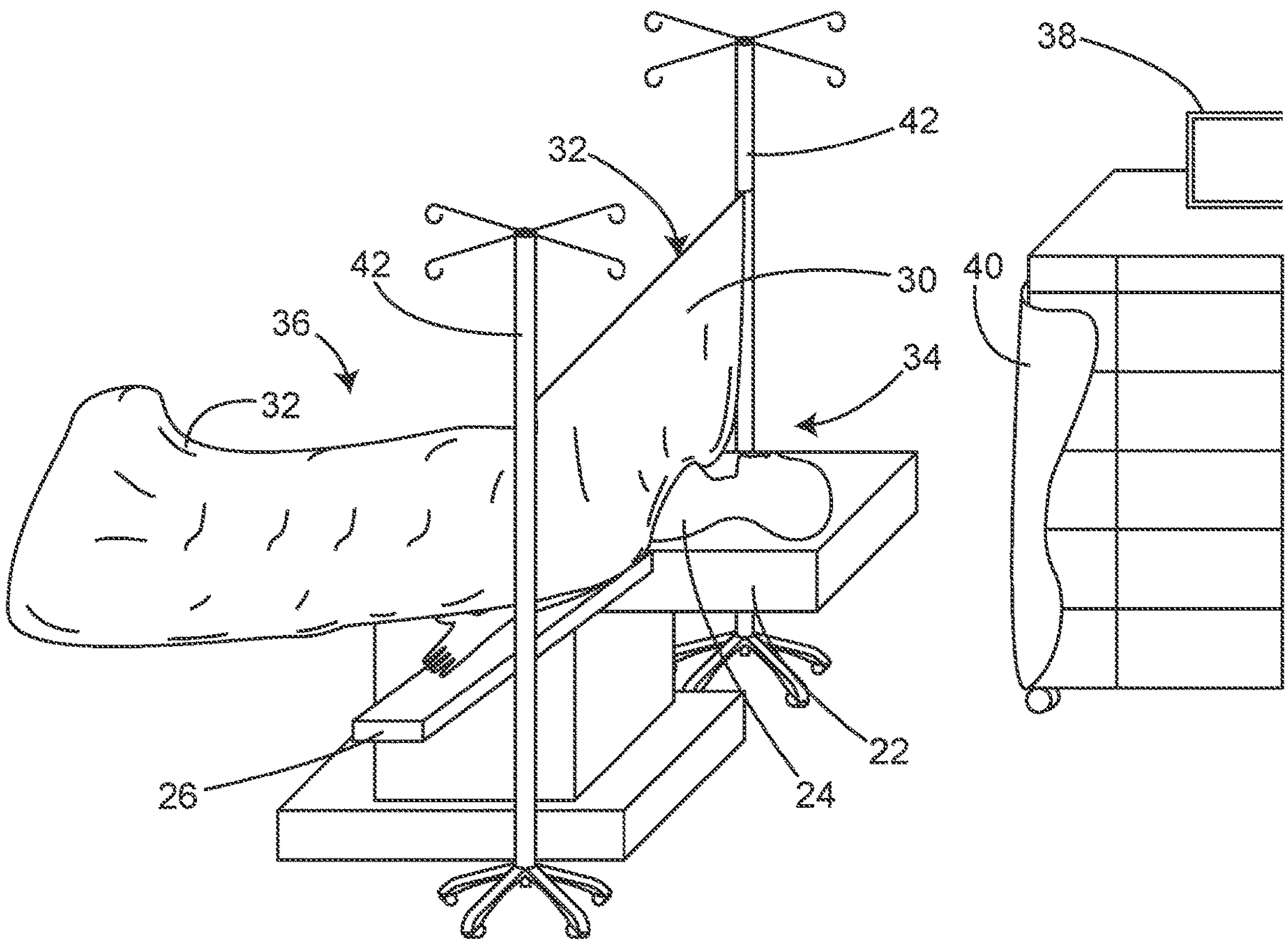


Fig. 3

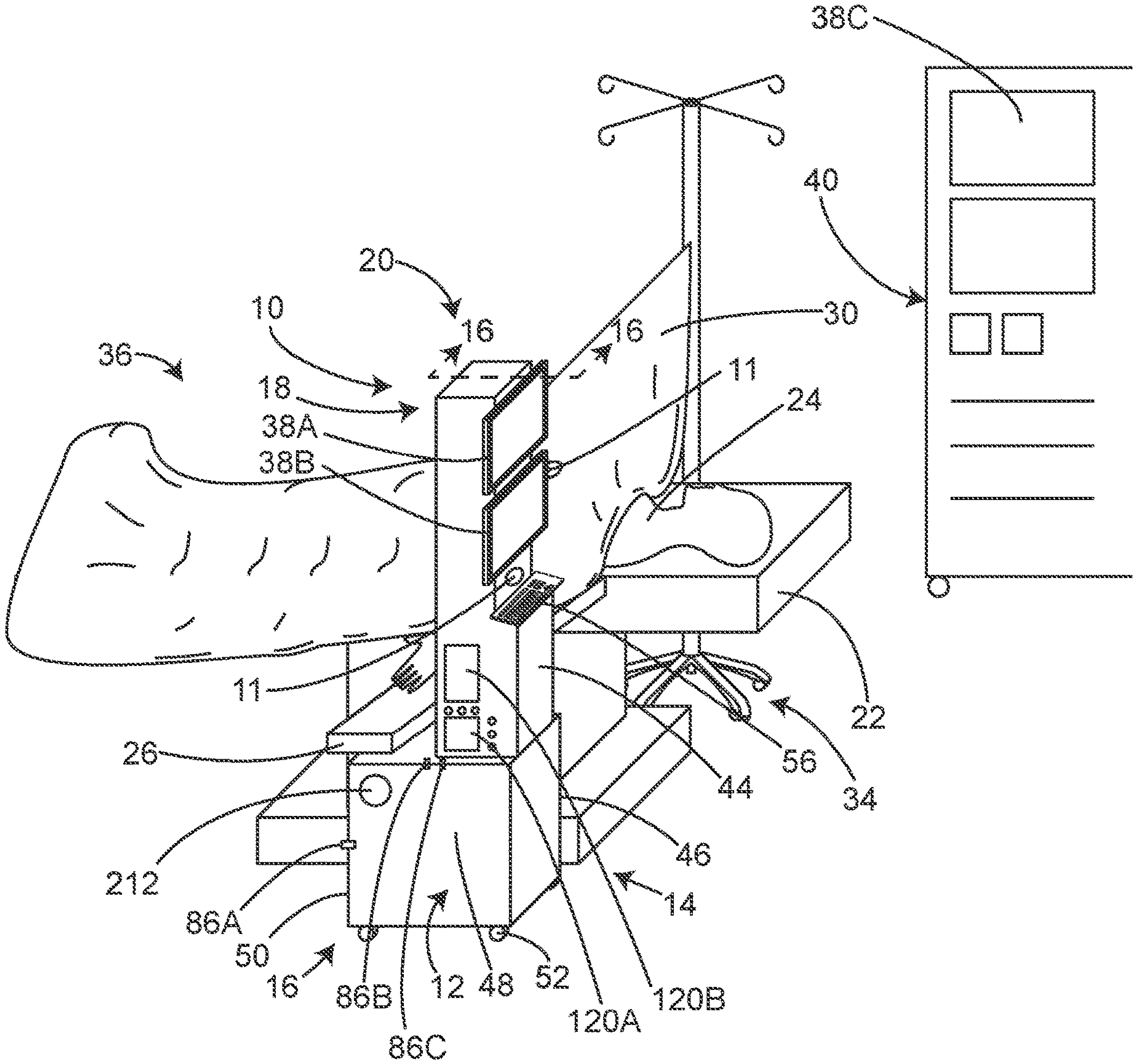

38C
40
20
10
16
16
30
36
18
11
24
38A
38B
11
22
26
44
56
34
212
46
14
86A
50
16
86B
12
48
52
120A
120B
86C

Fig. 4

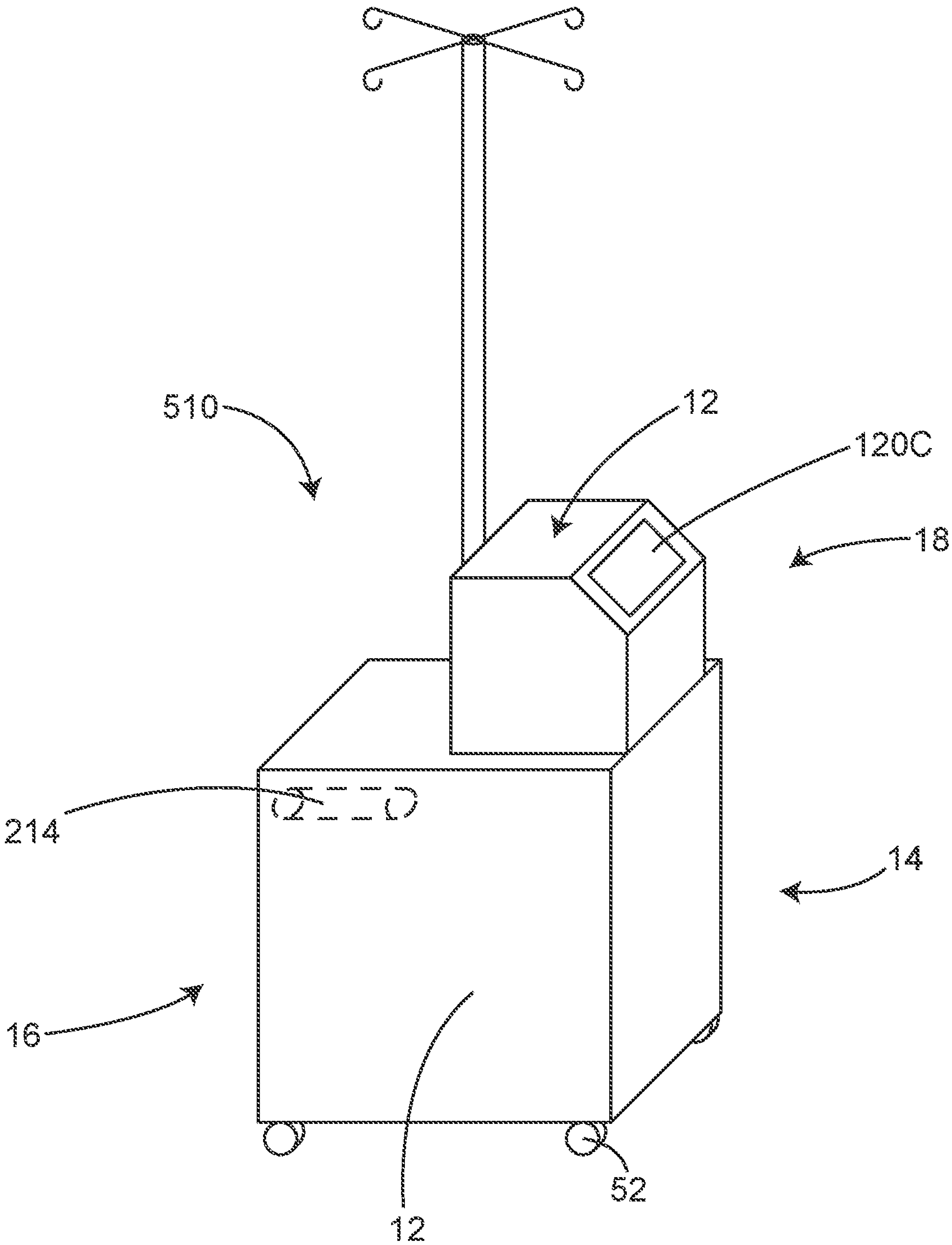


Fig. 5

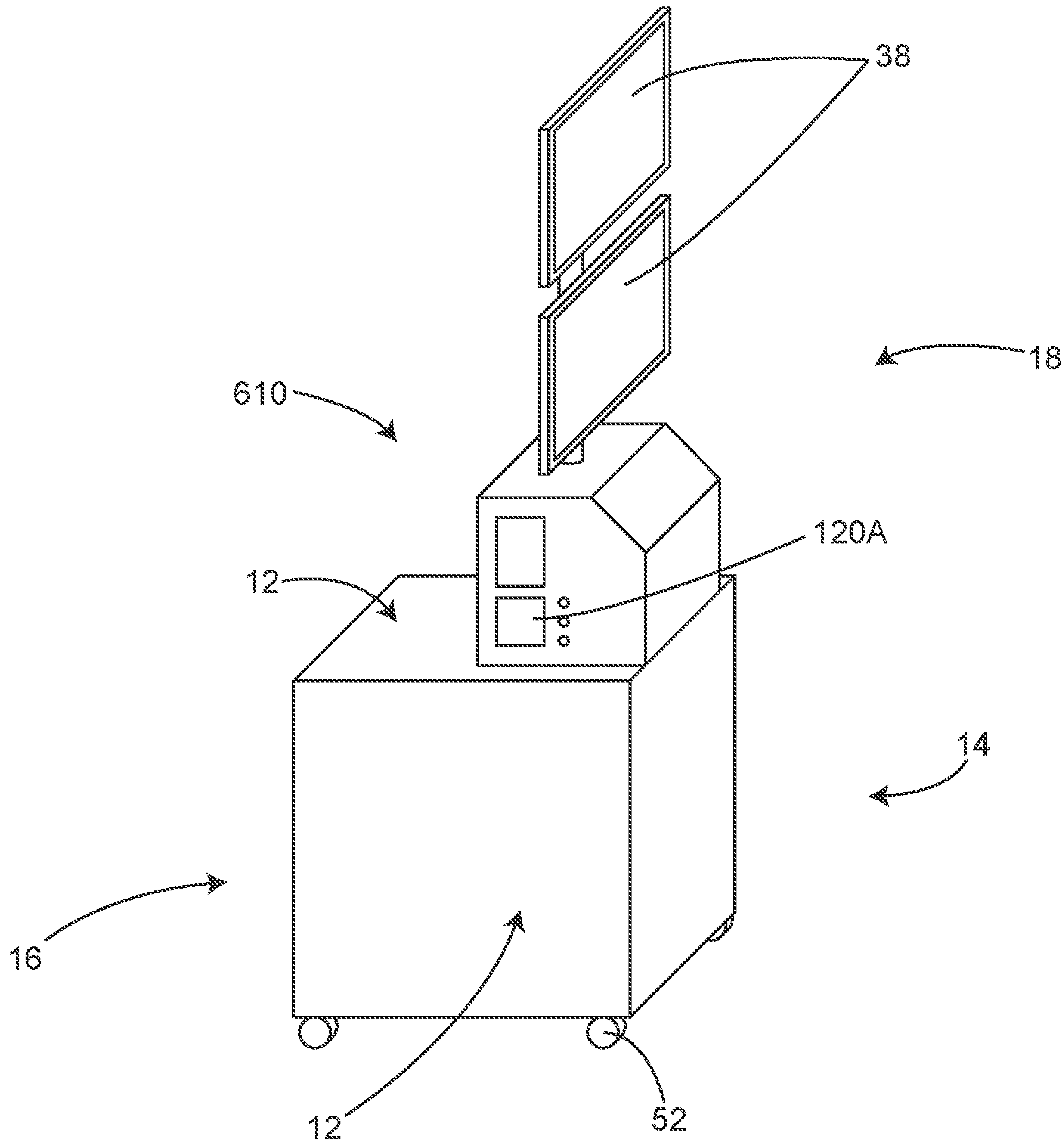


Fig. 6

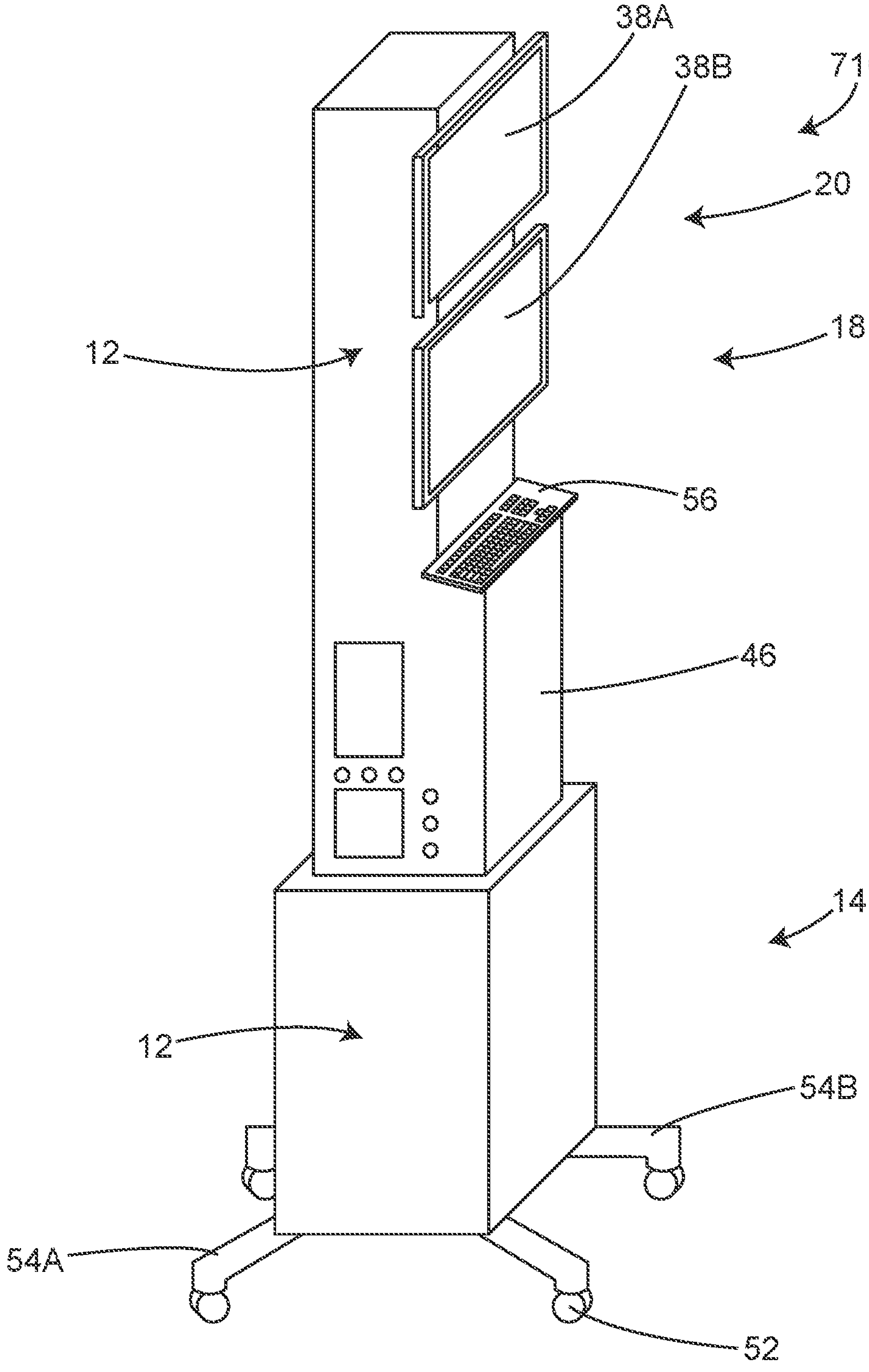


Fig. 7

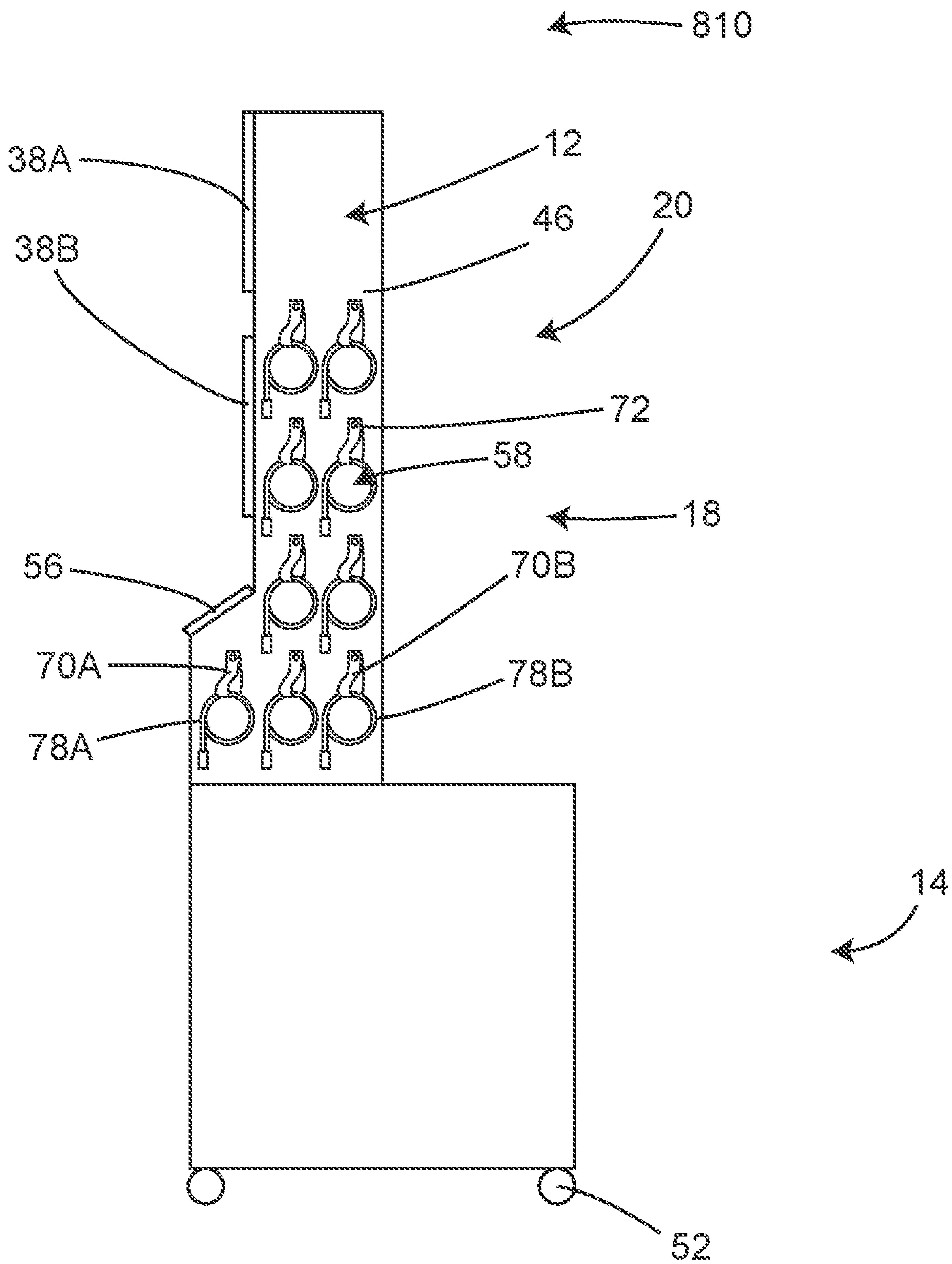


Fig. 8

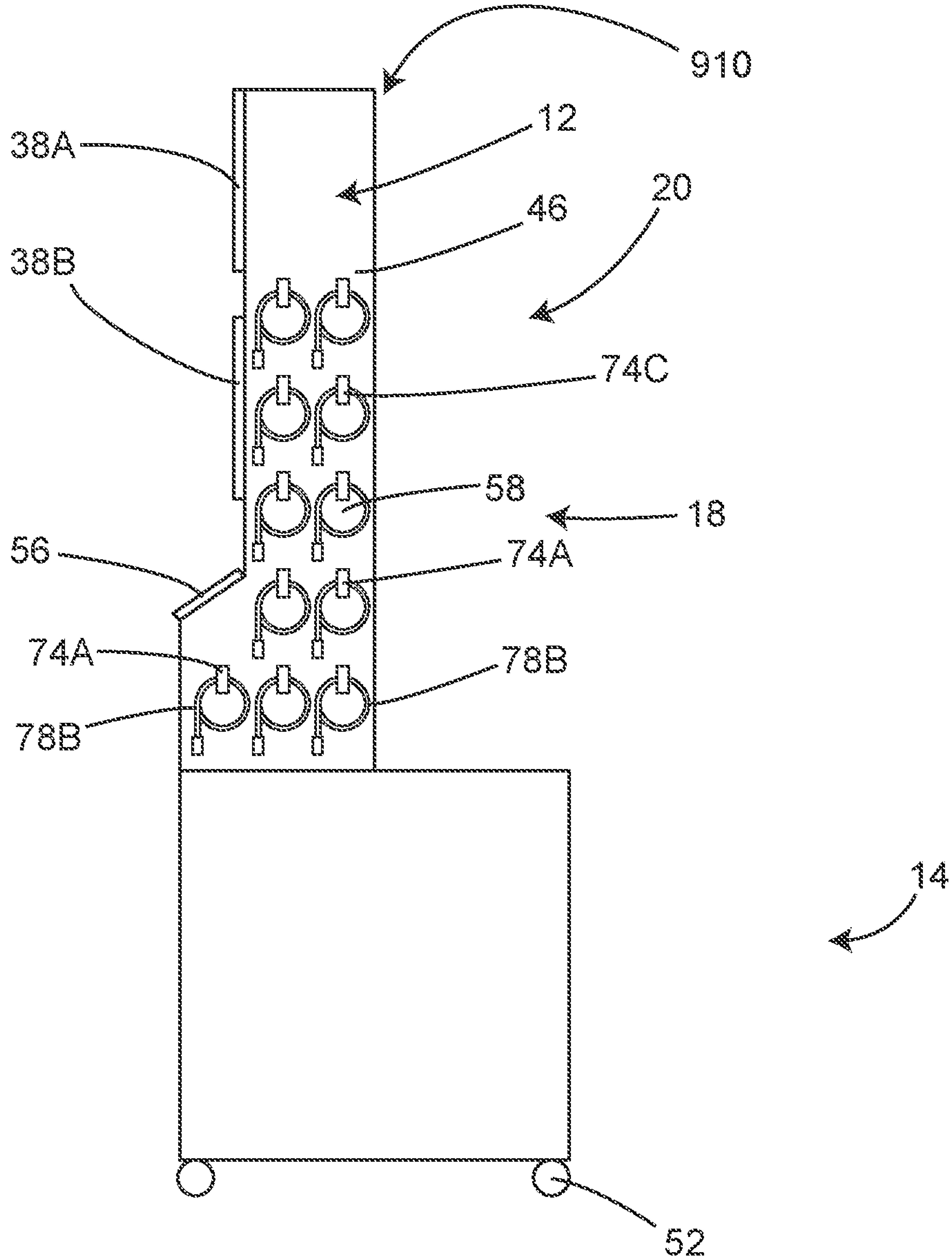


Fig. 9

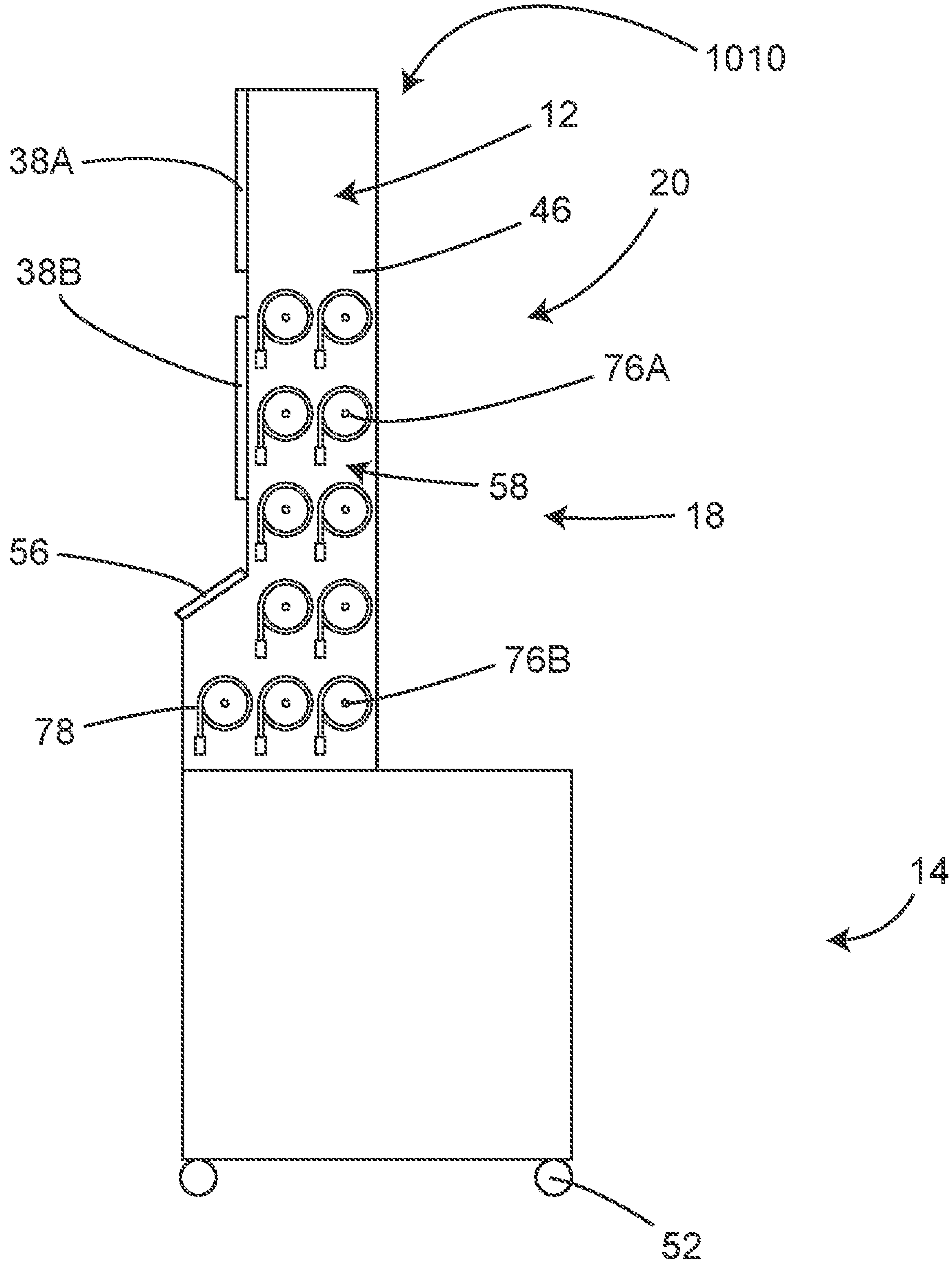


Fig. 10

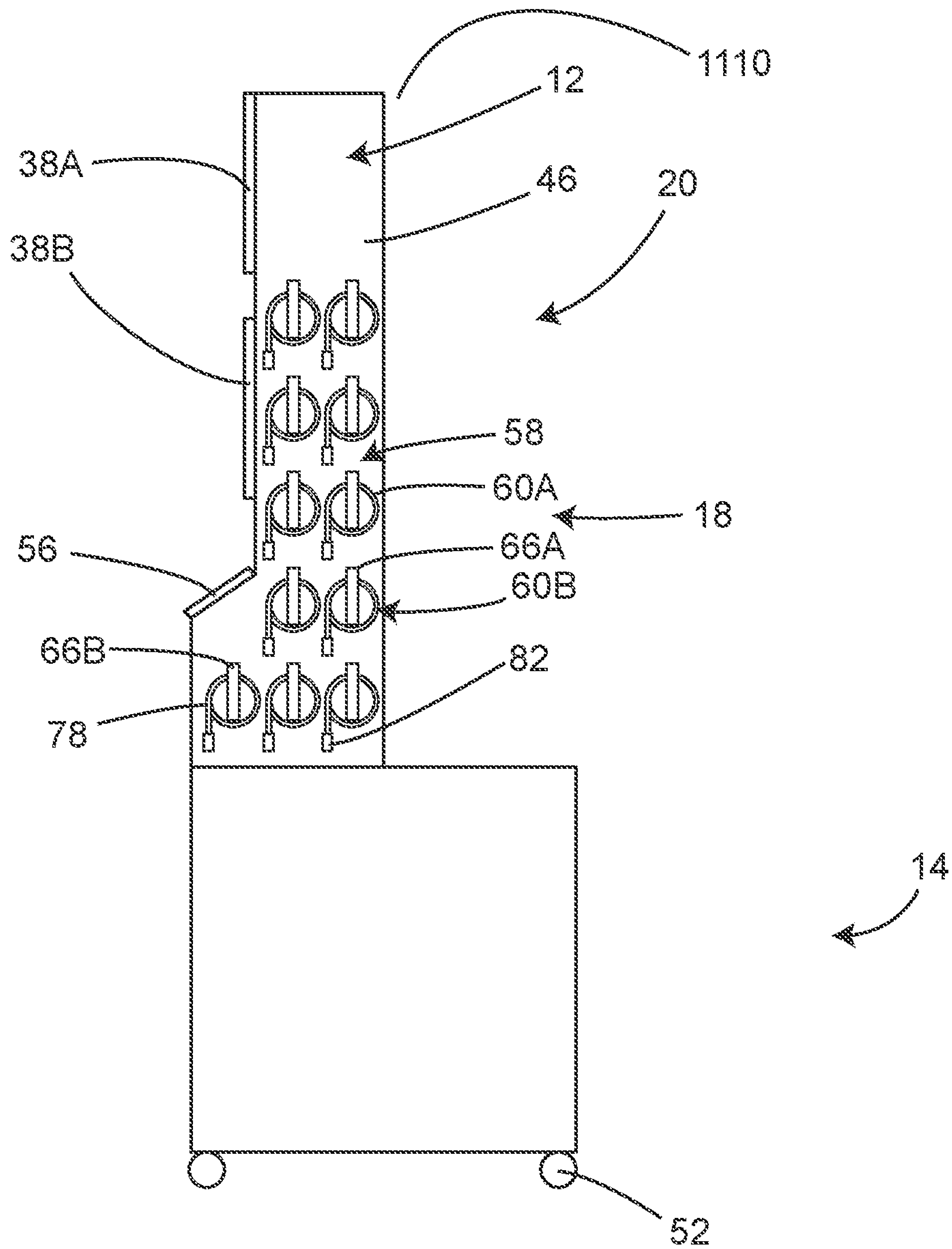


Fig. 11

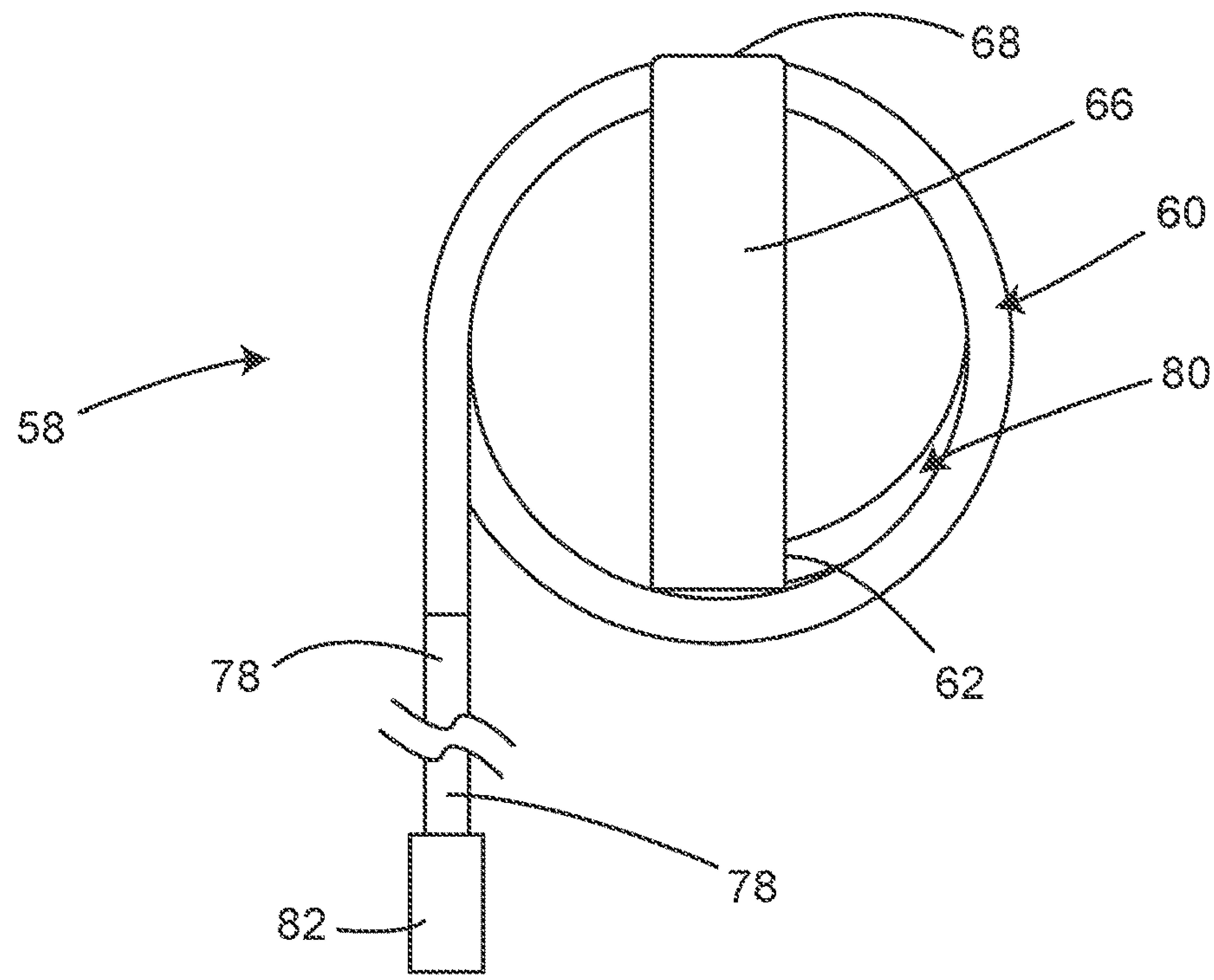


Fig. 12

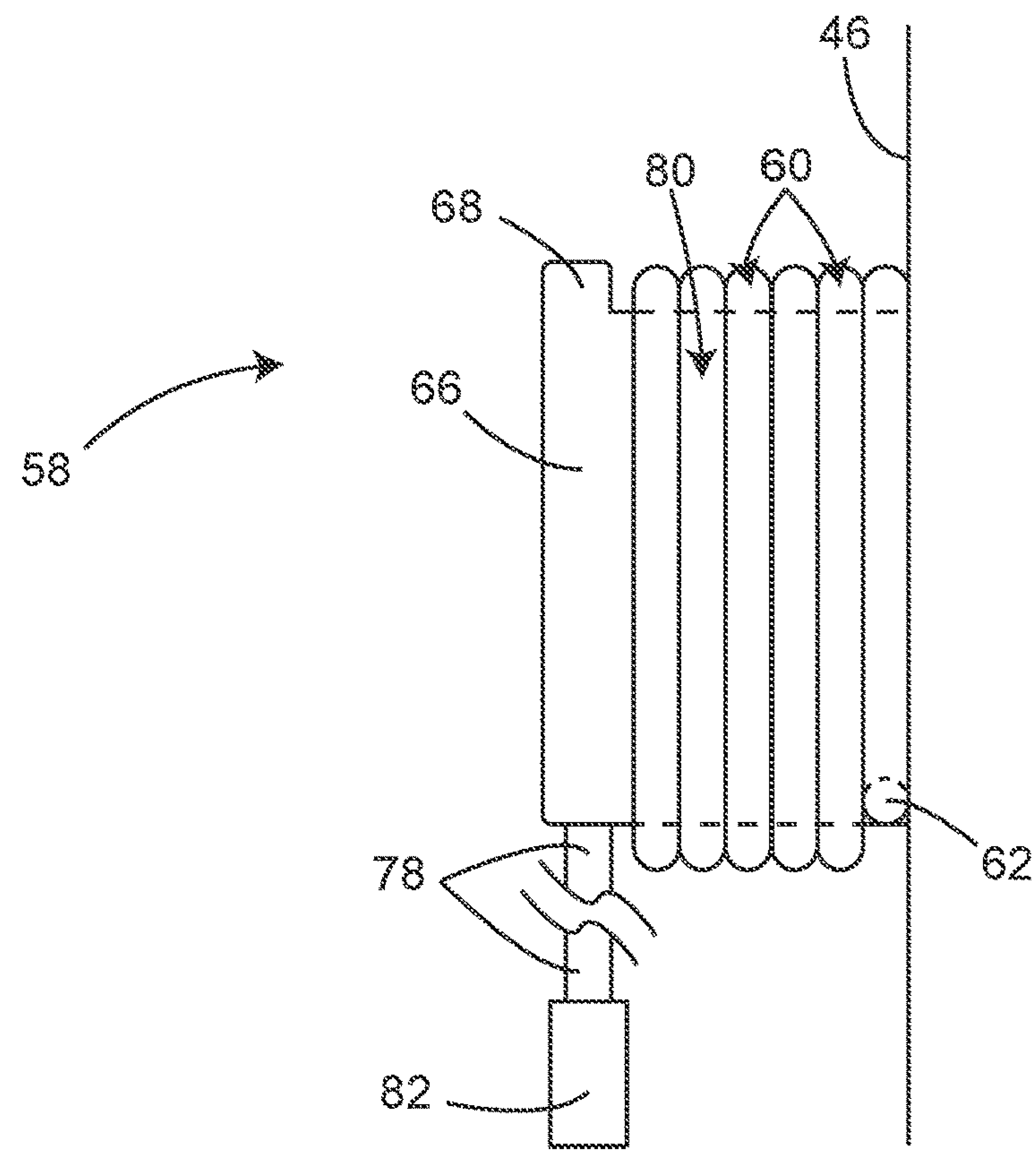


Fig. 13

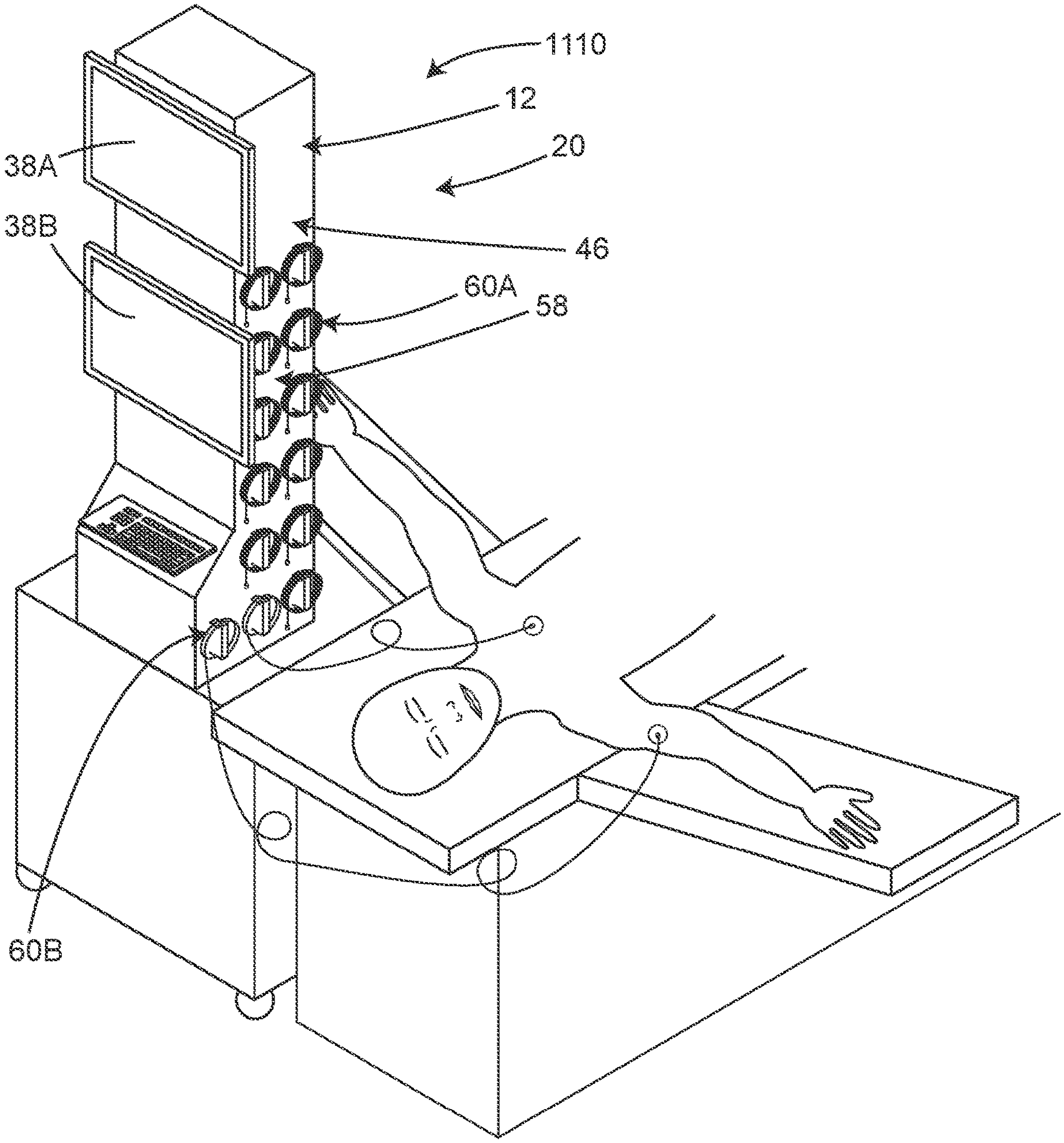


Fig. 14

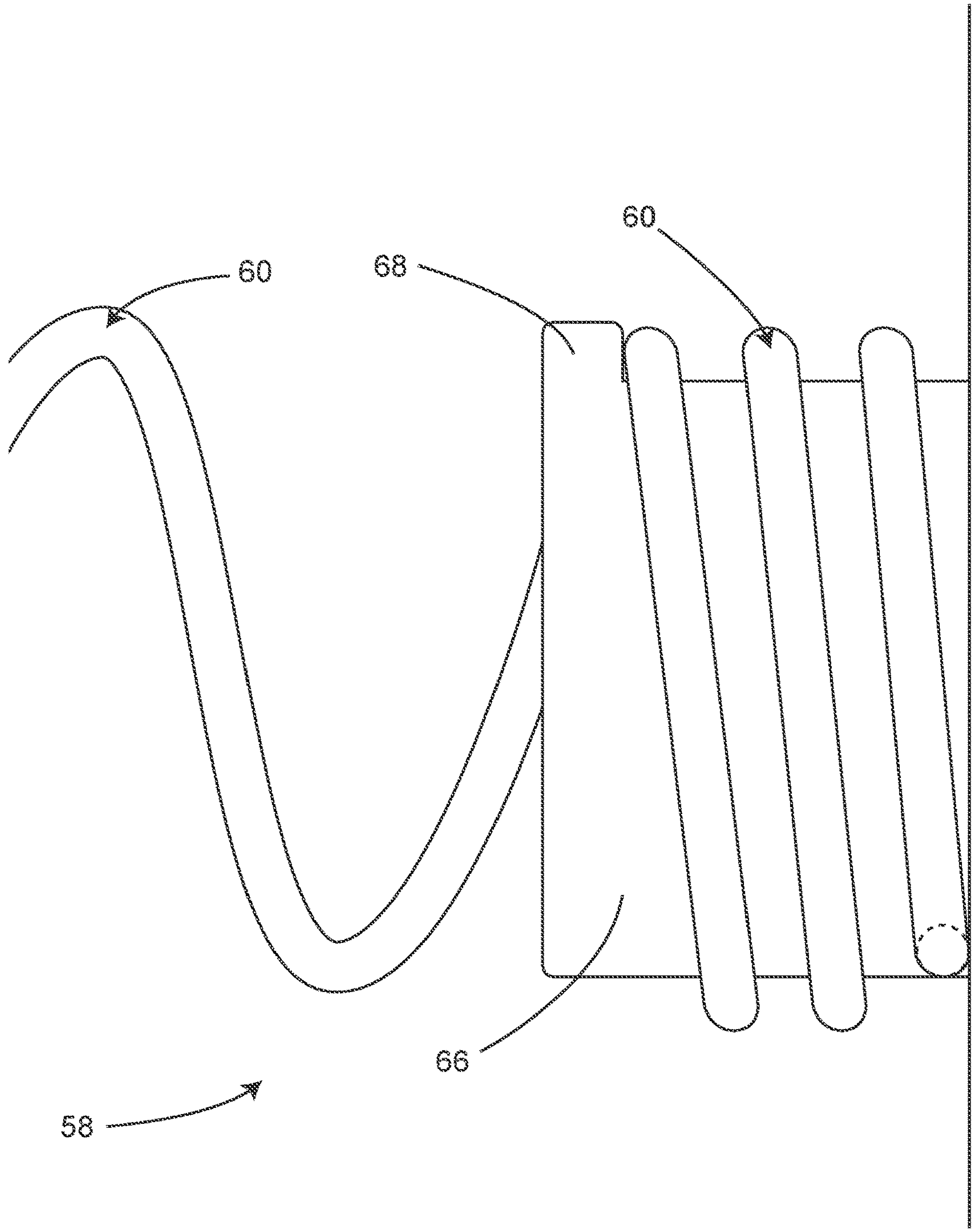


Fig. 15

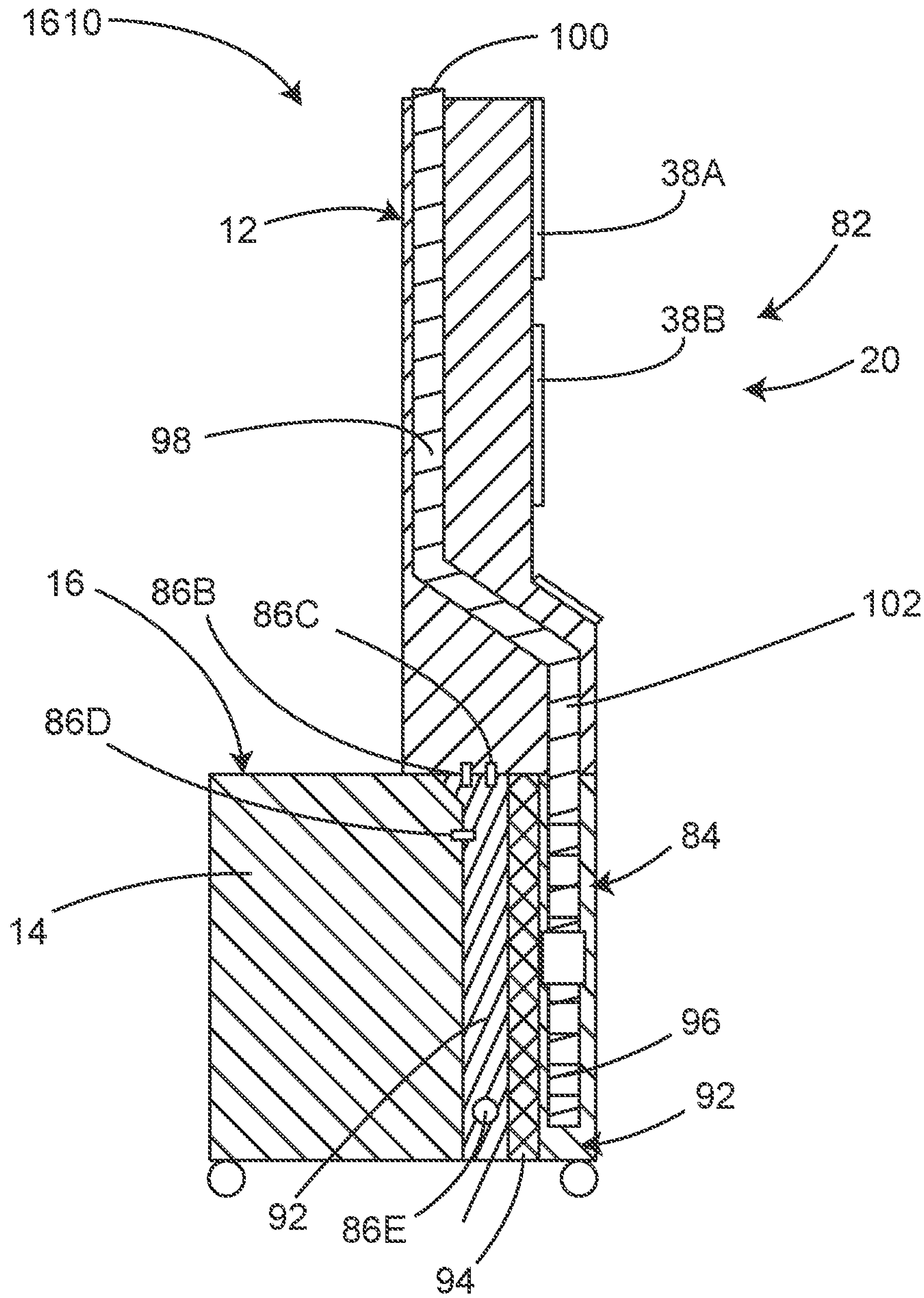

1610
100
38A
82
12
38B
20
98
16
86B
86C
102
86D
84
14
96
92
92
86E
94

Fig. 16

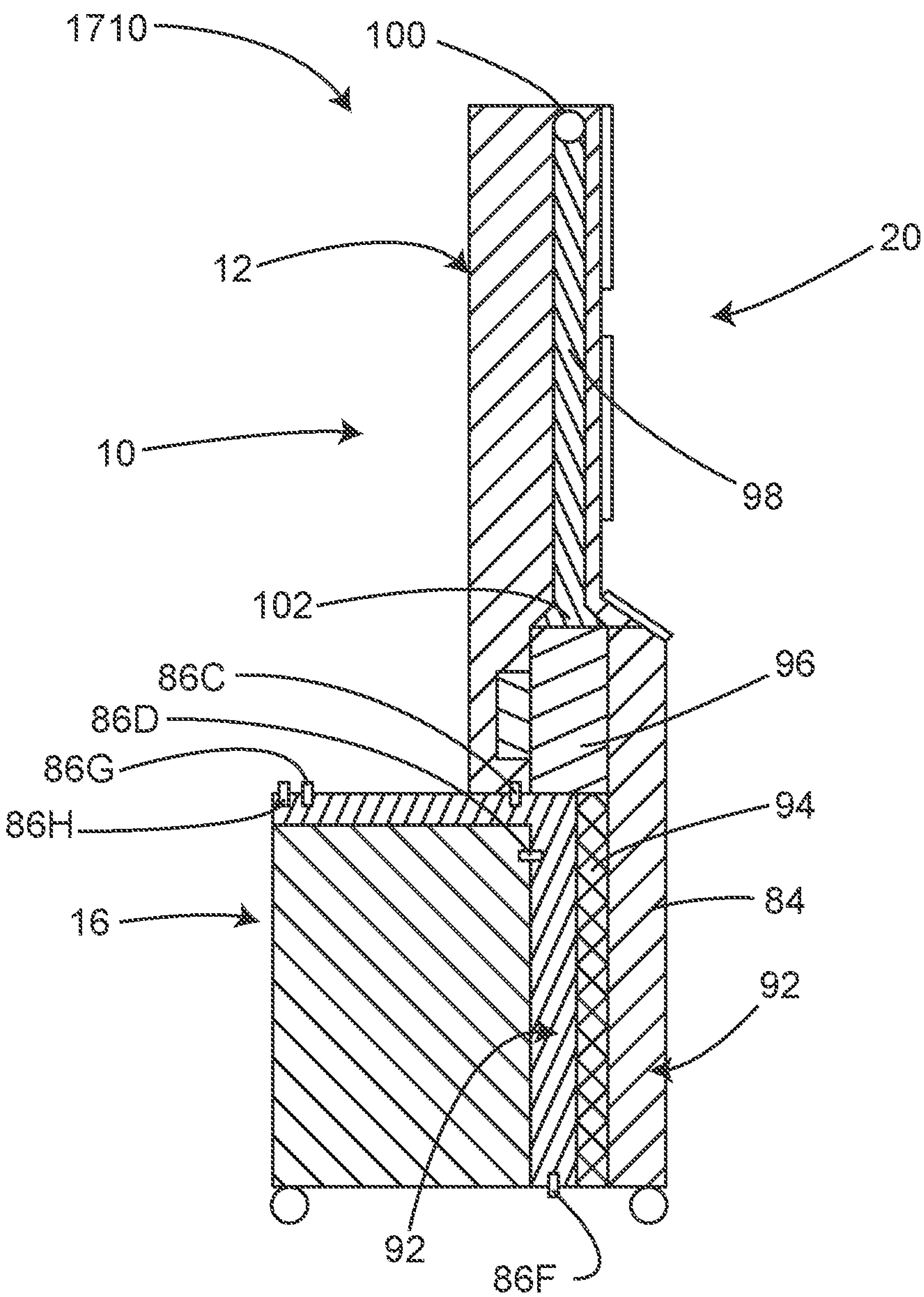


Fig. 17

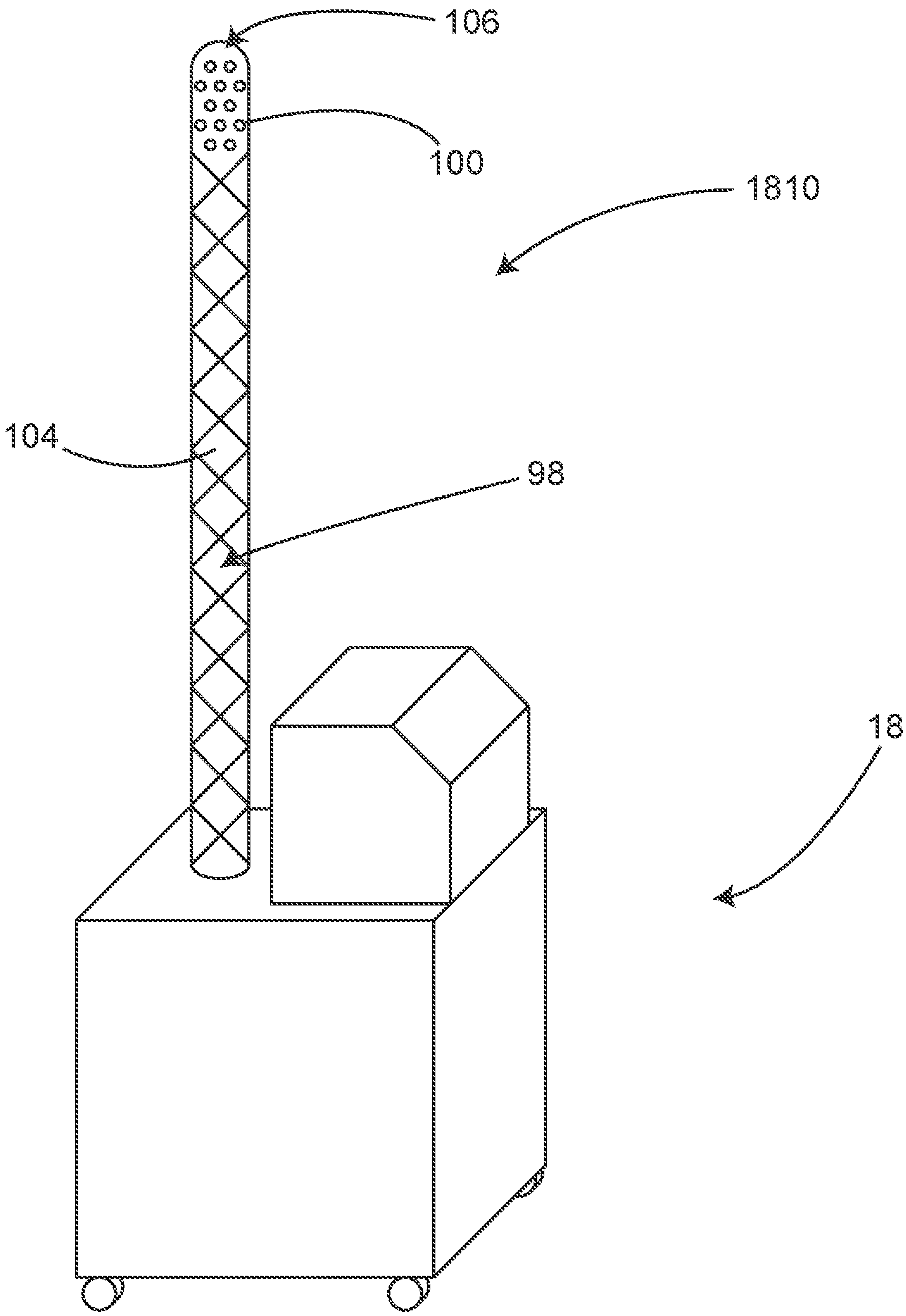


Fig. 18

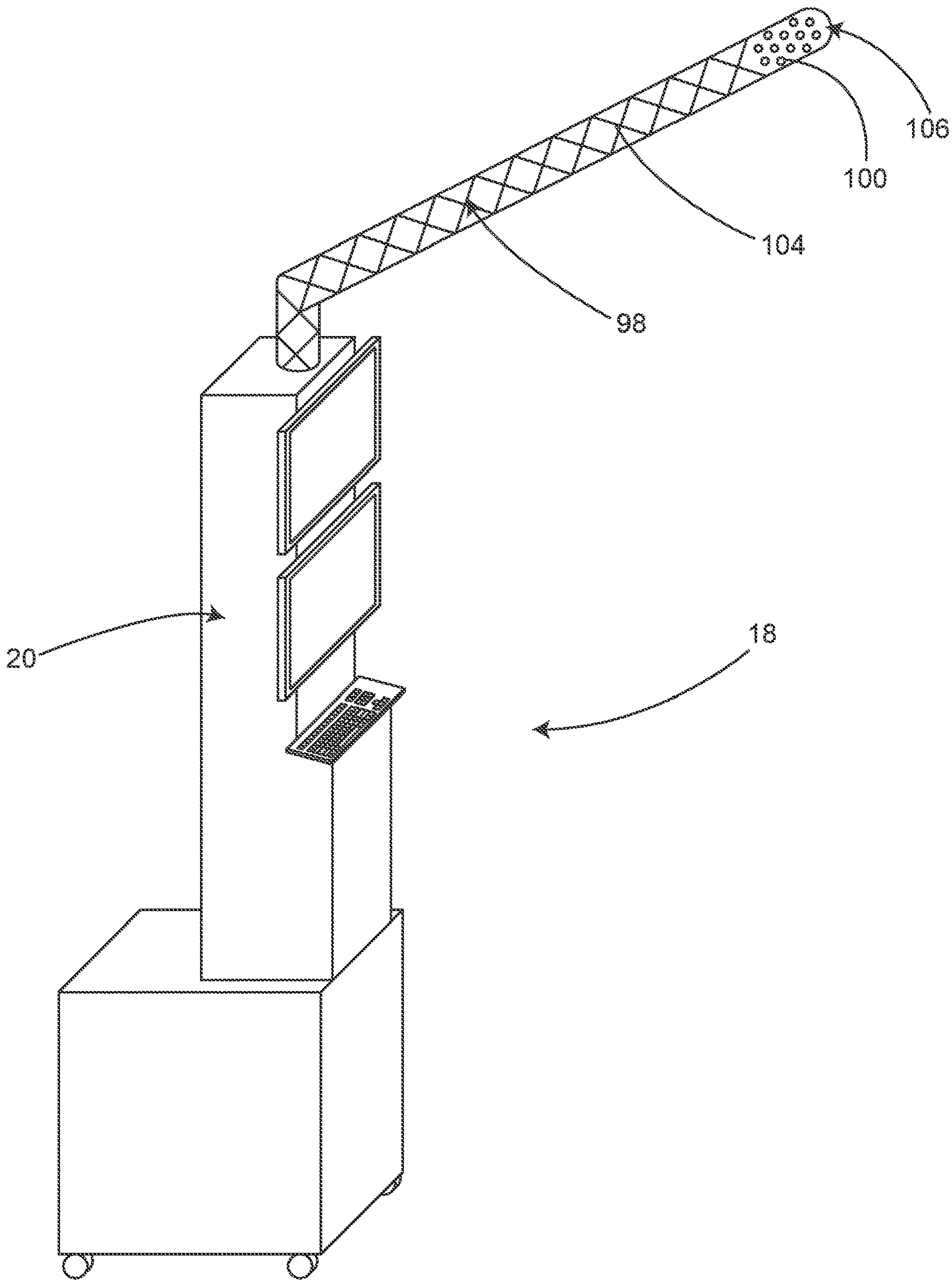


Fig. 19

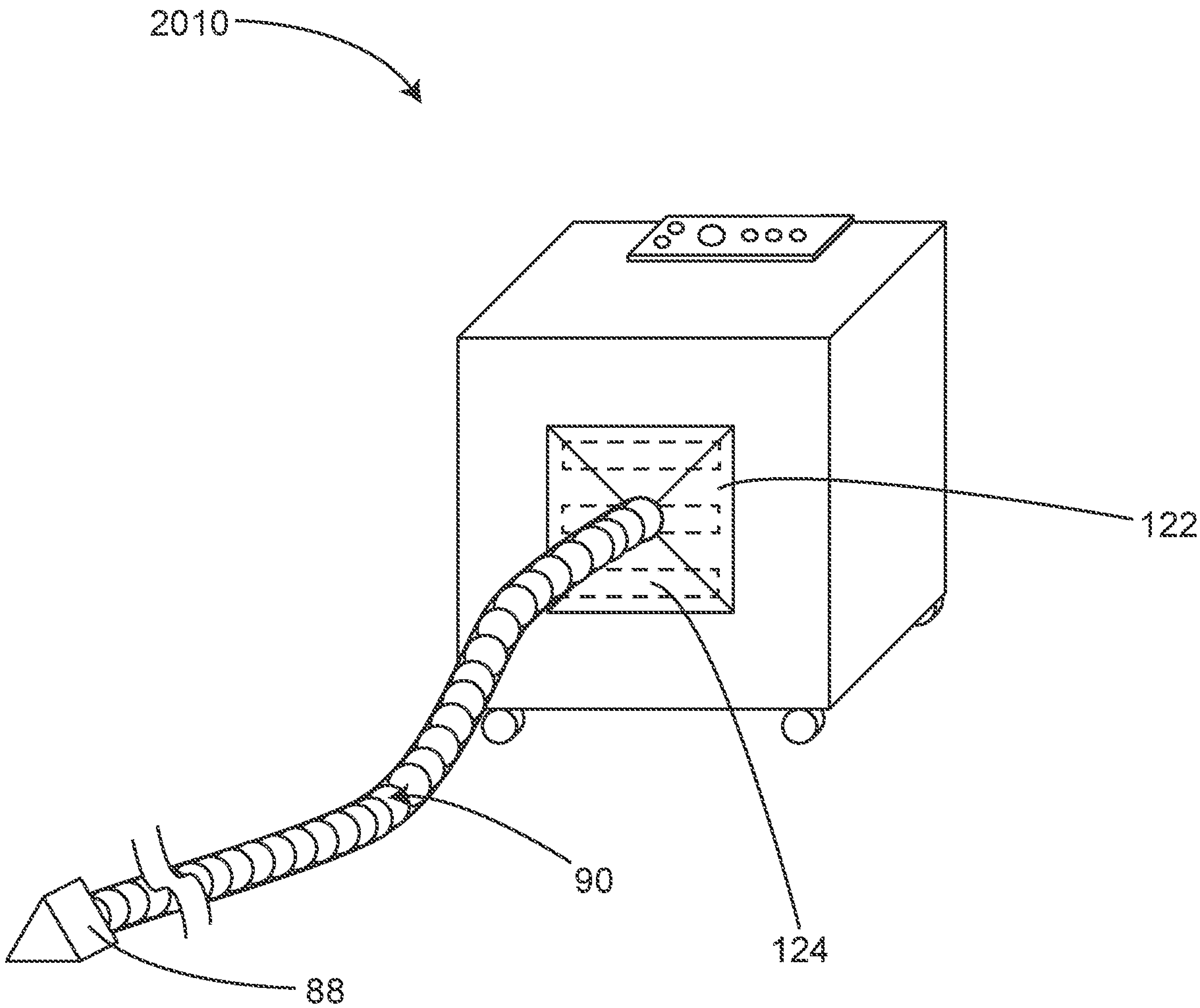


Fig. 20

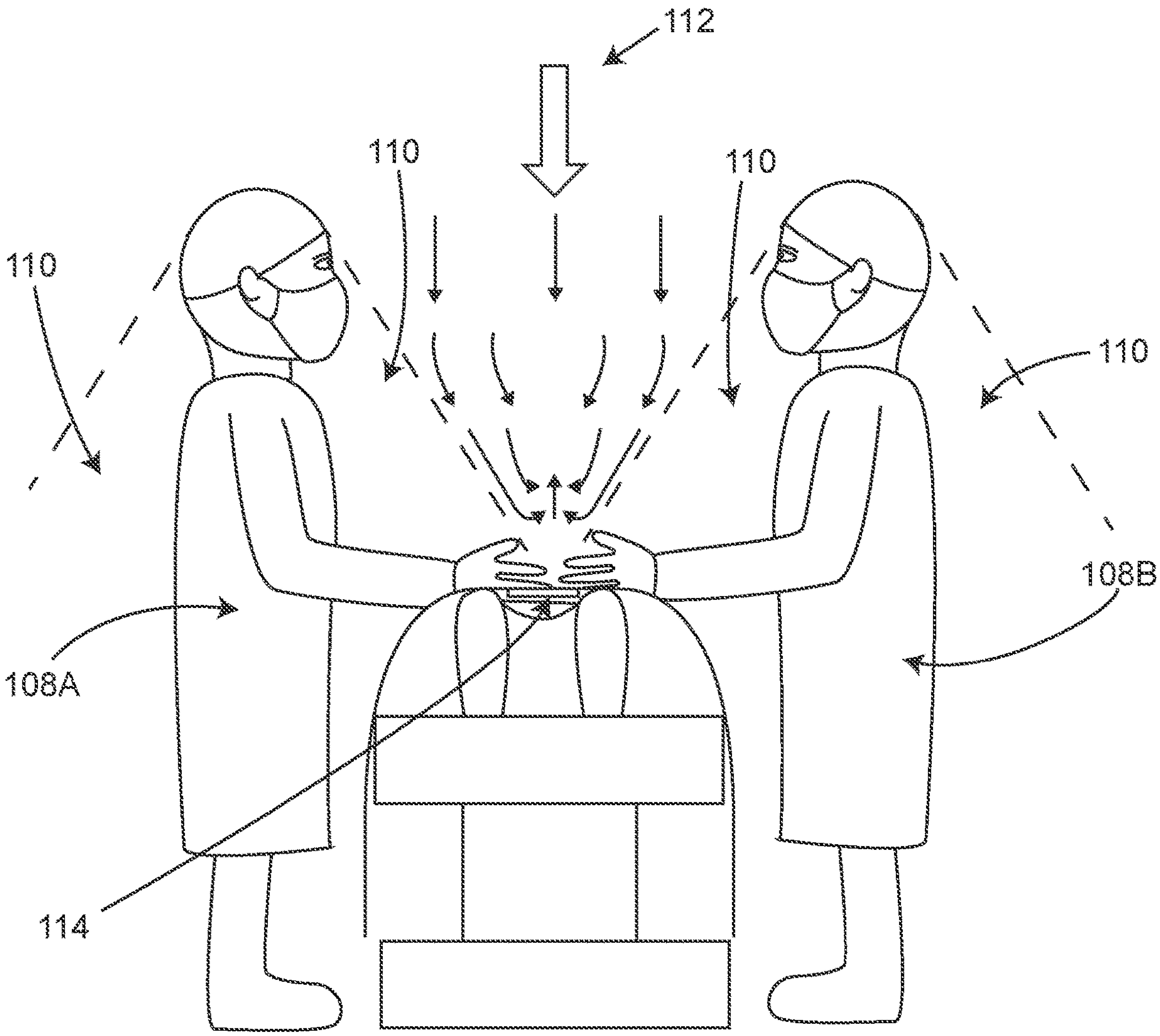


Fig. 21A

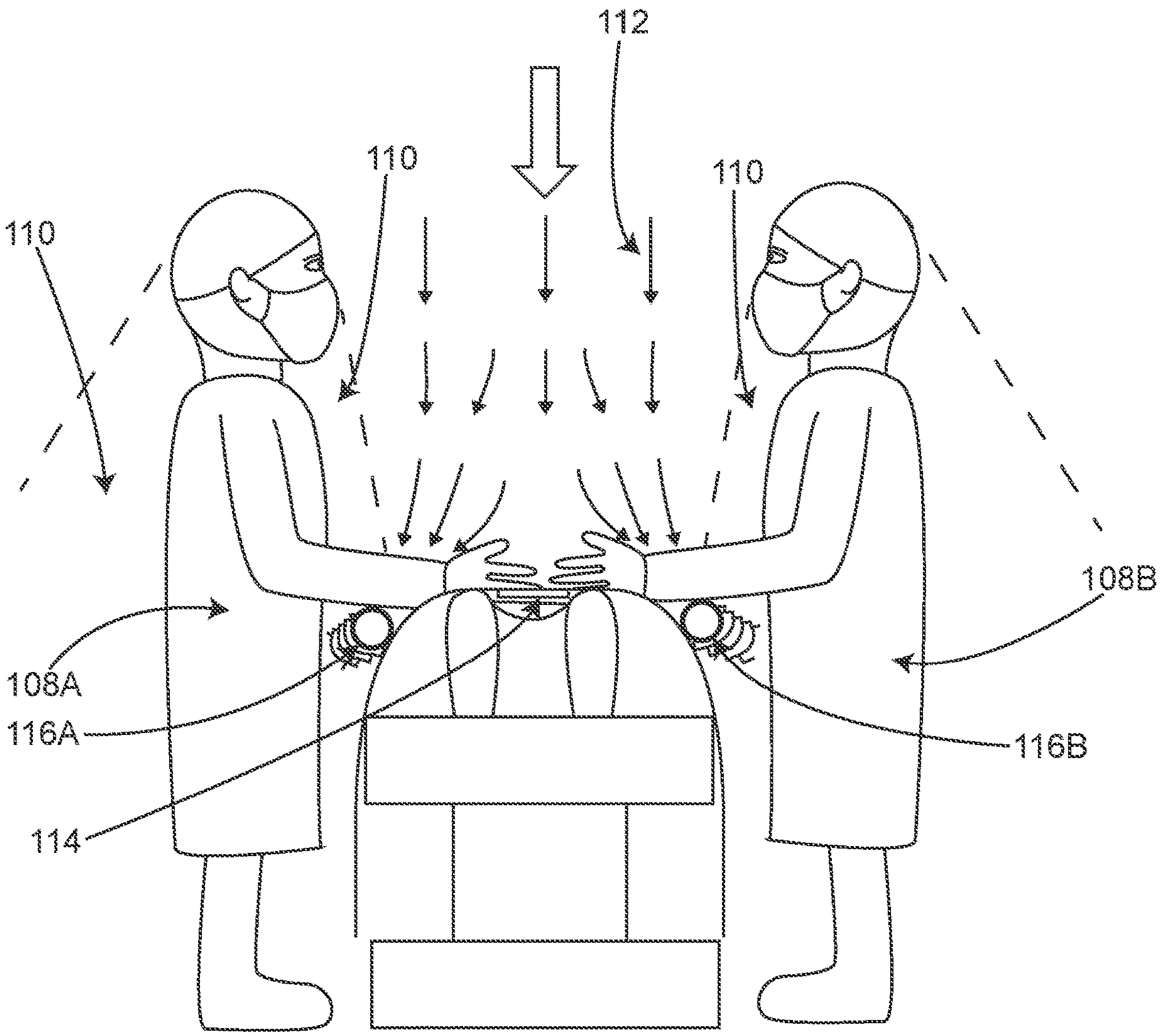


Fig. 21B

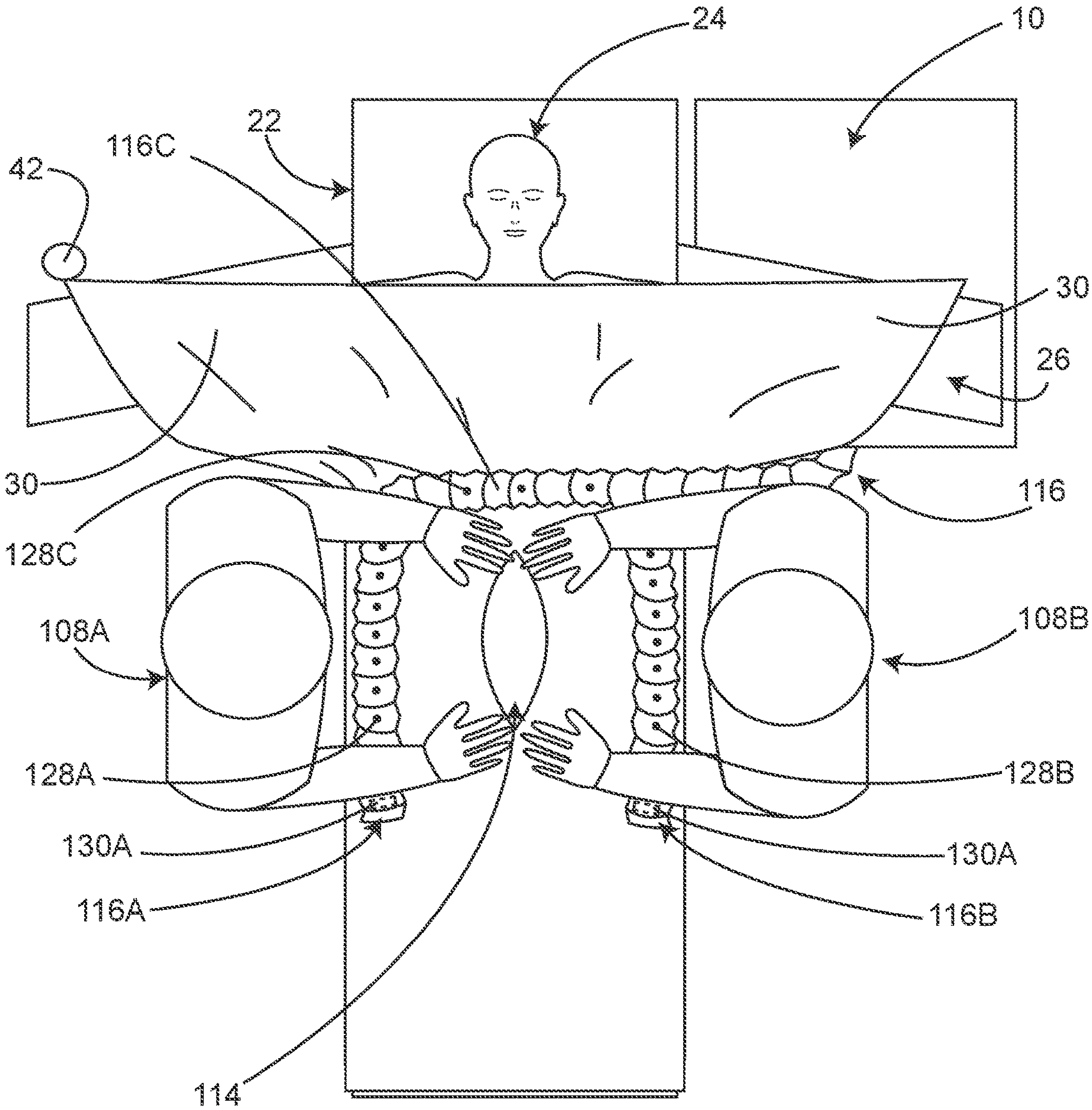

24
10
22
116C
42
30
26
30
116
128C
108A
108B
128A
128B
130A
130A
116A
116B
114

Fig. 21C

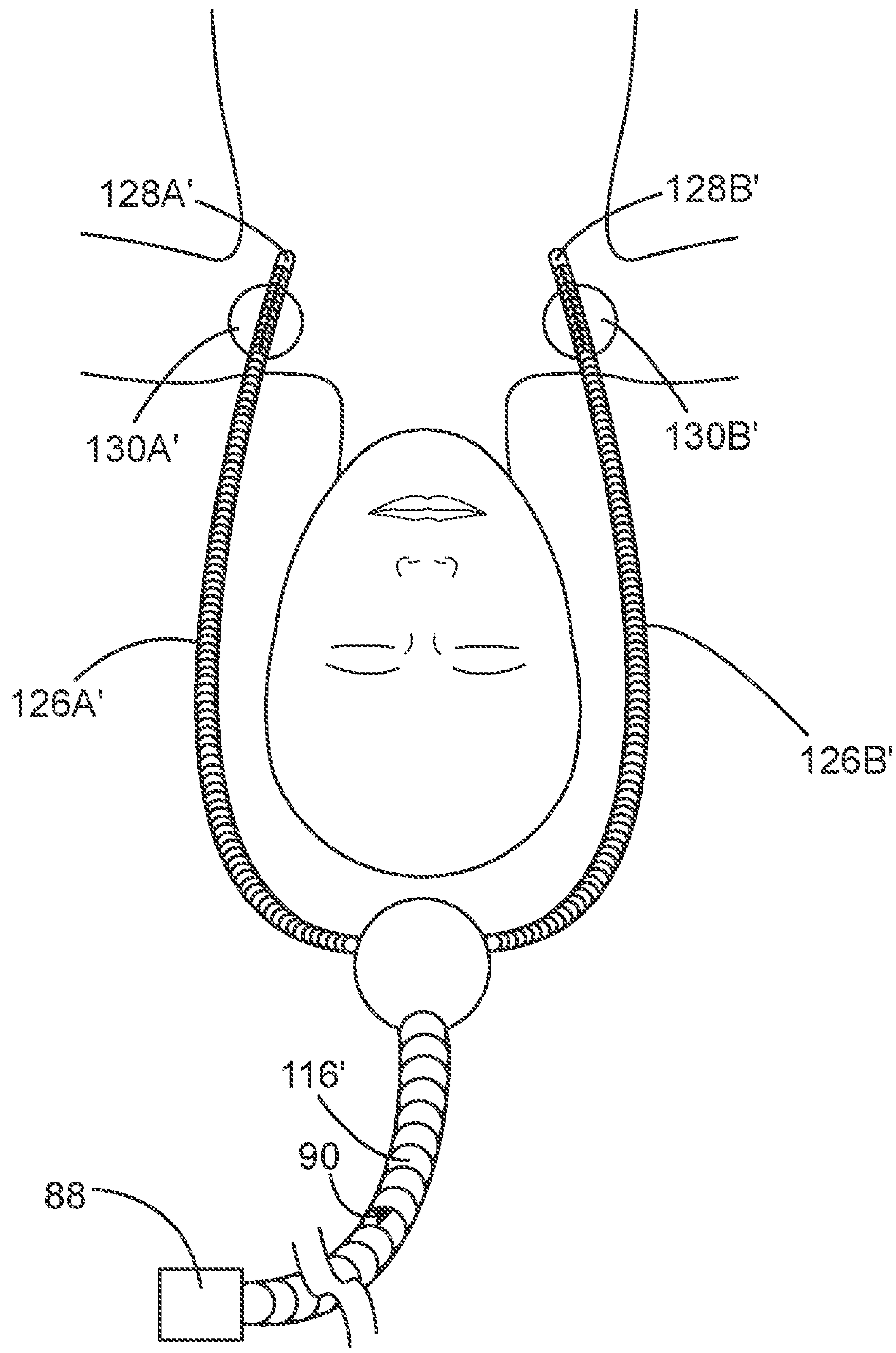


Fig. 22

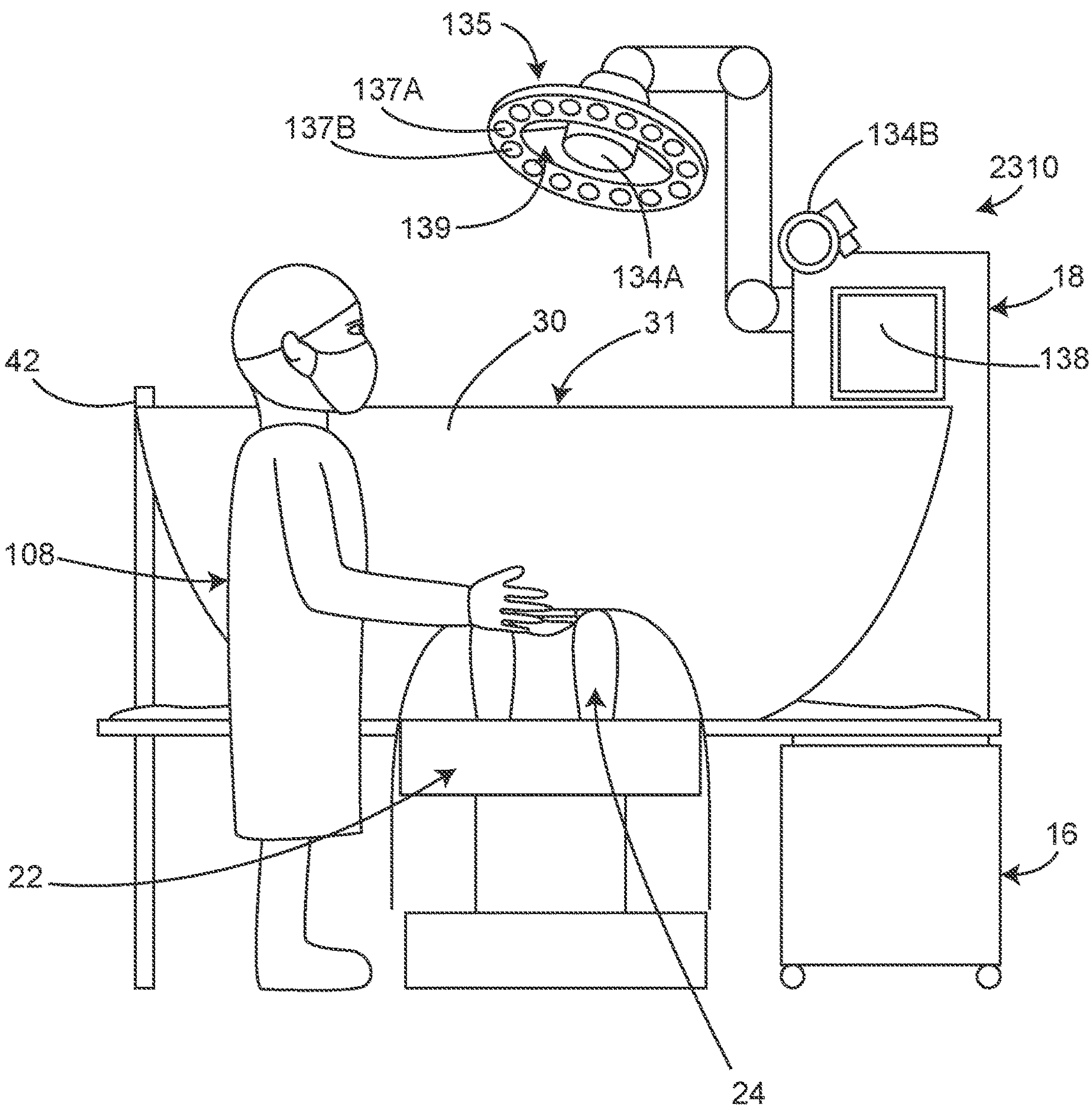


Fig. 23

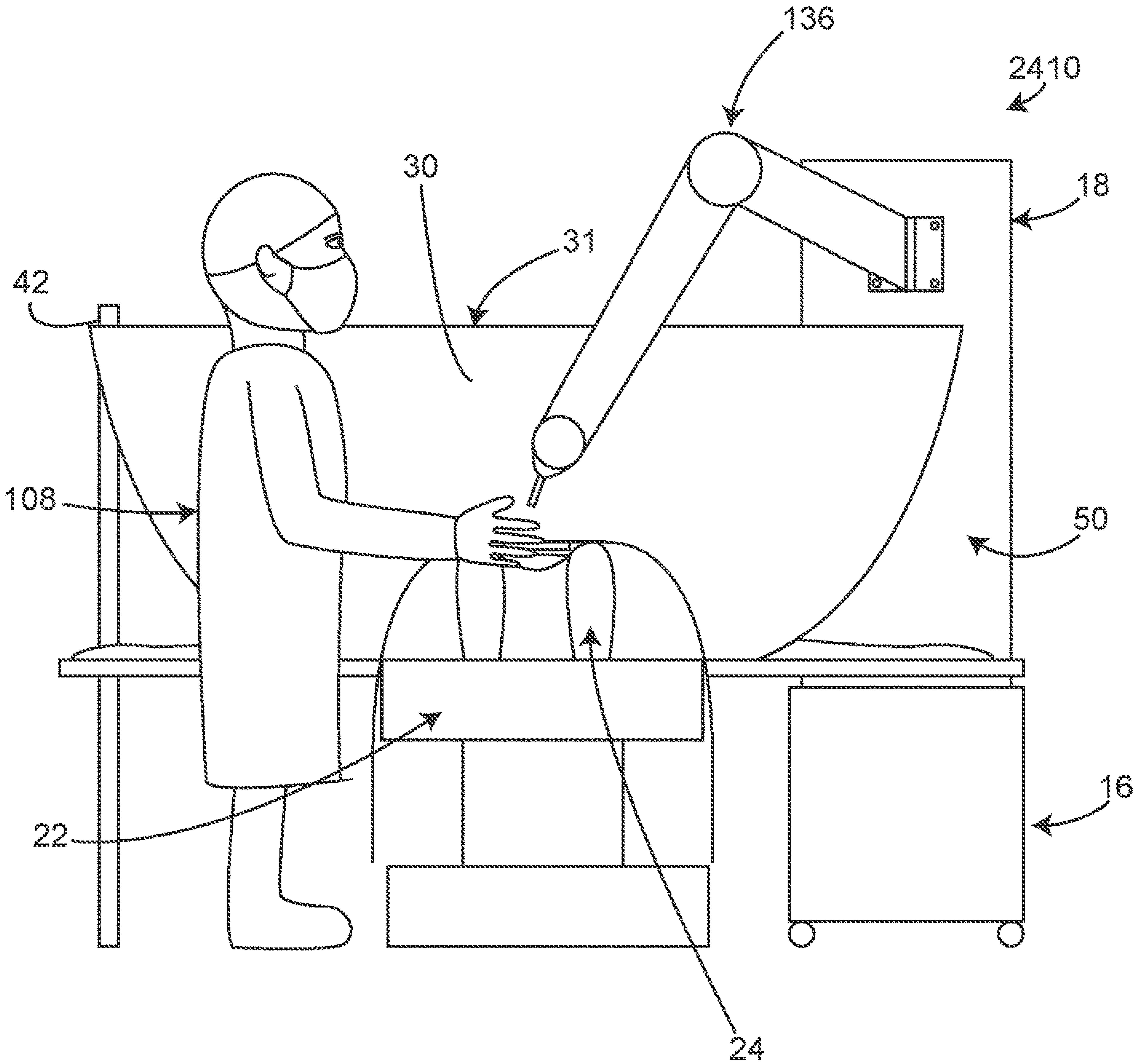


Fig. 24

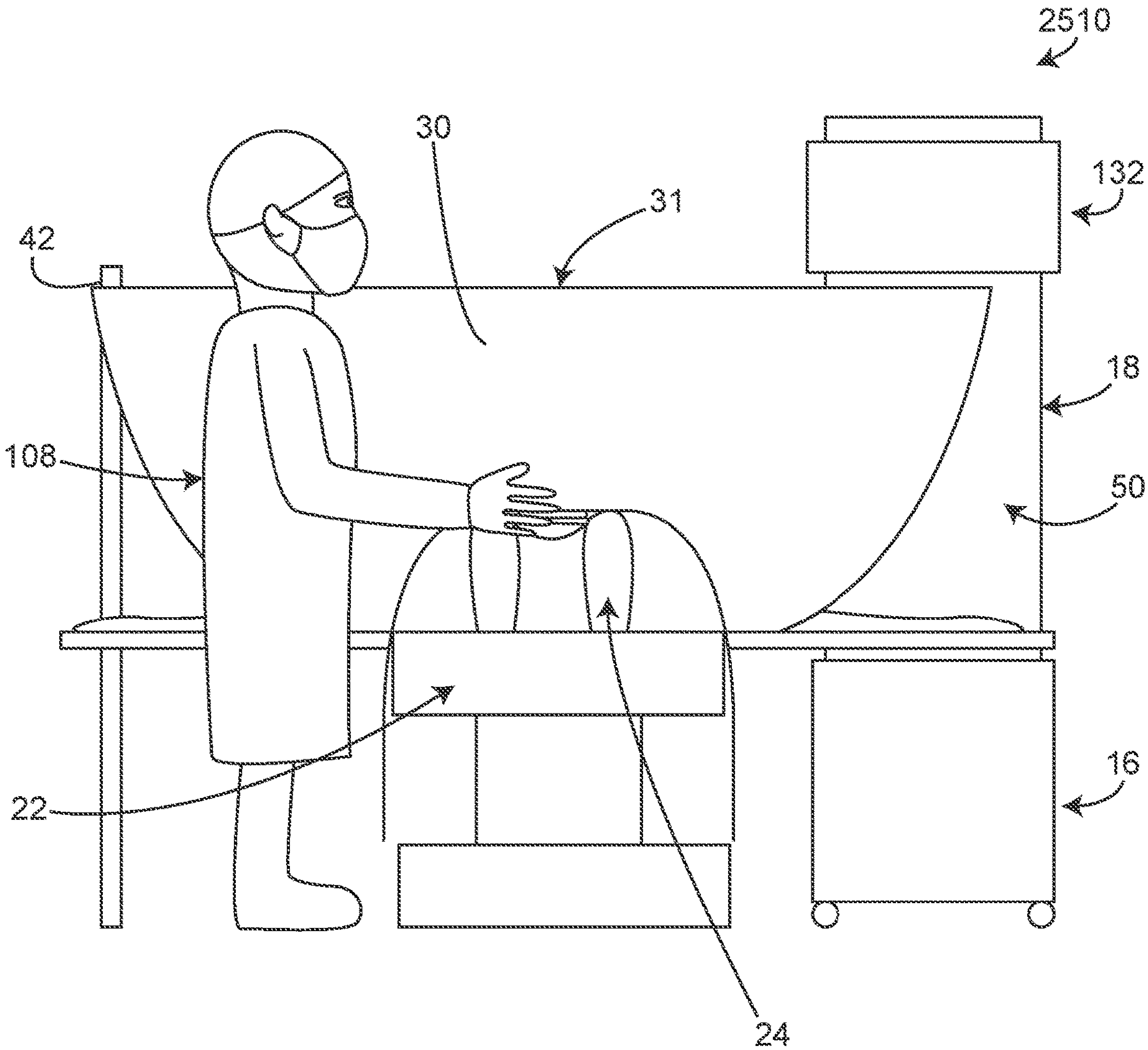


Fig. 25

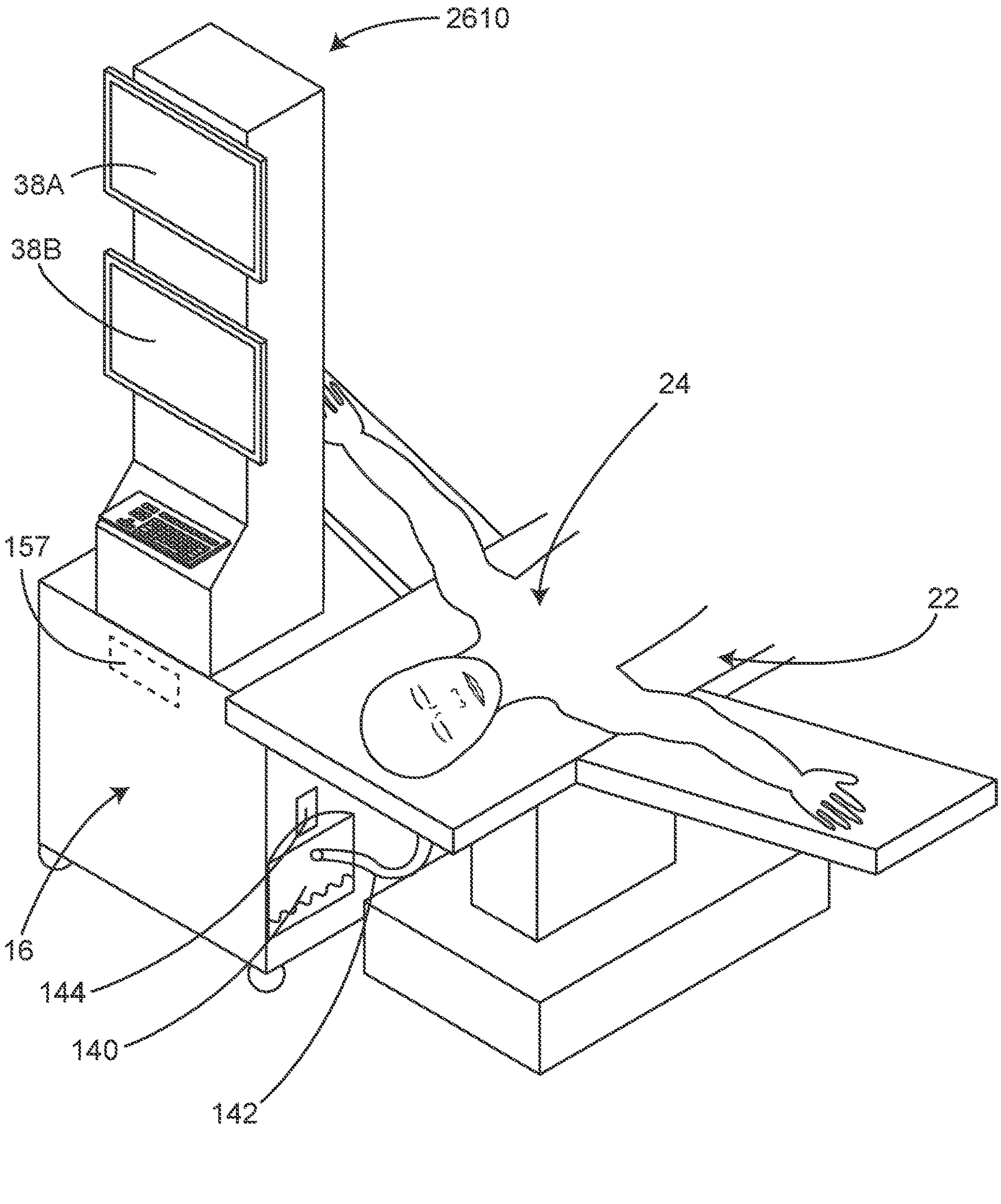


Fig. 26

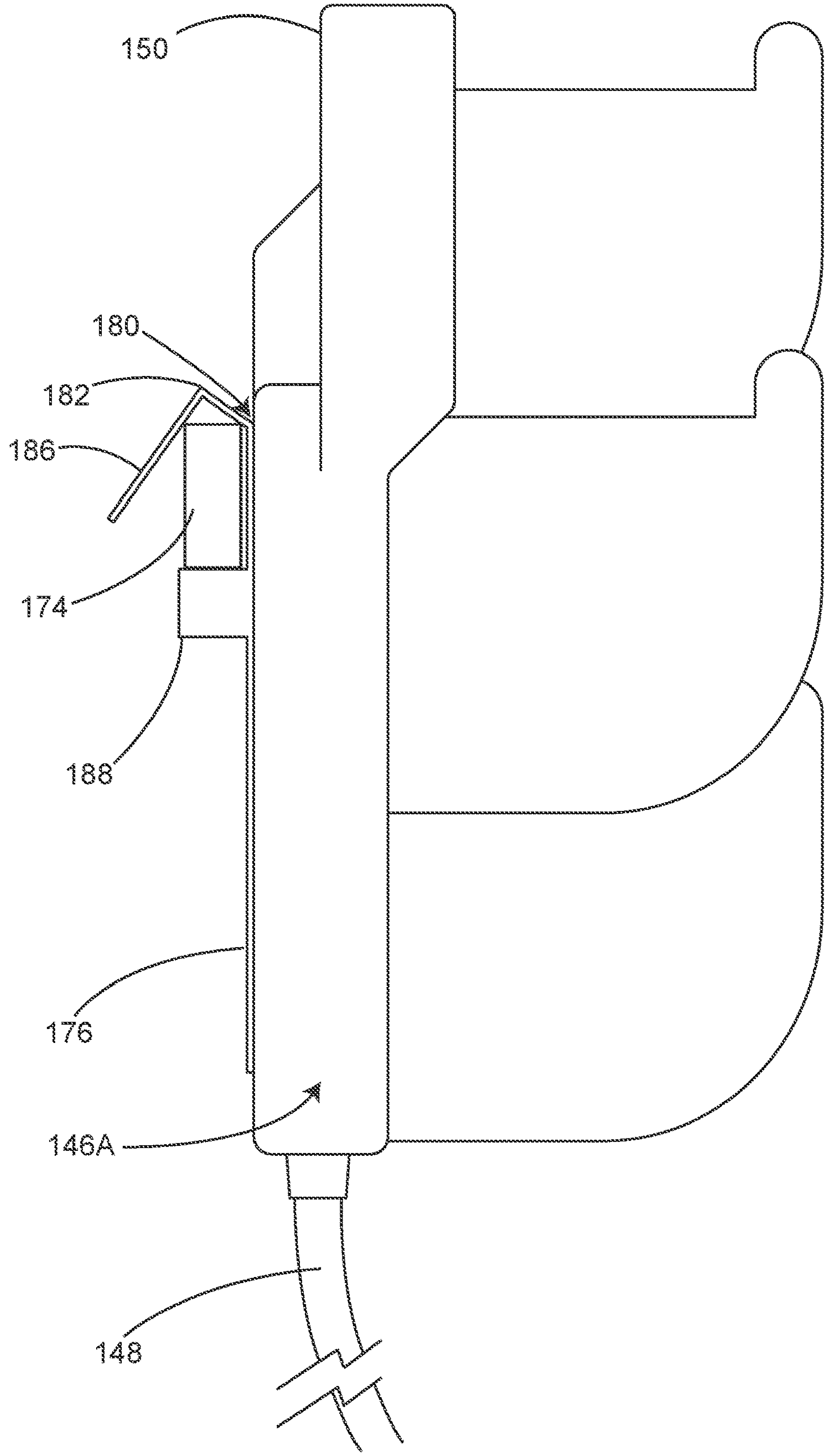


Fig. 27

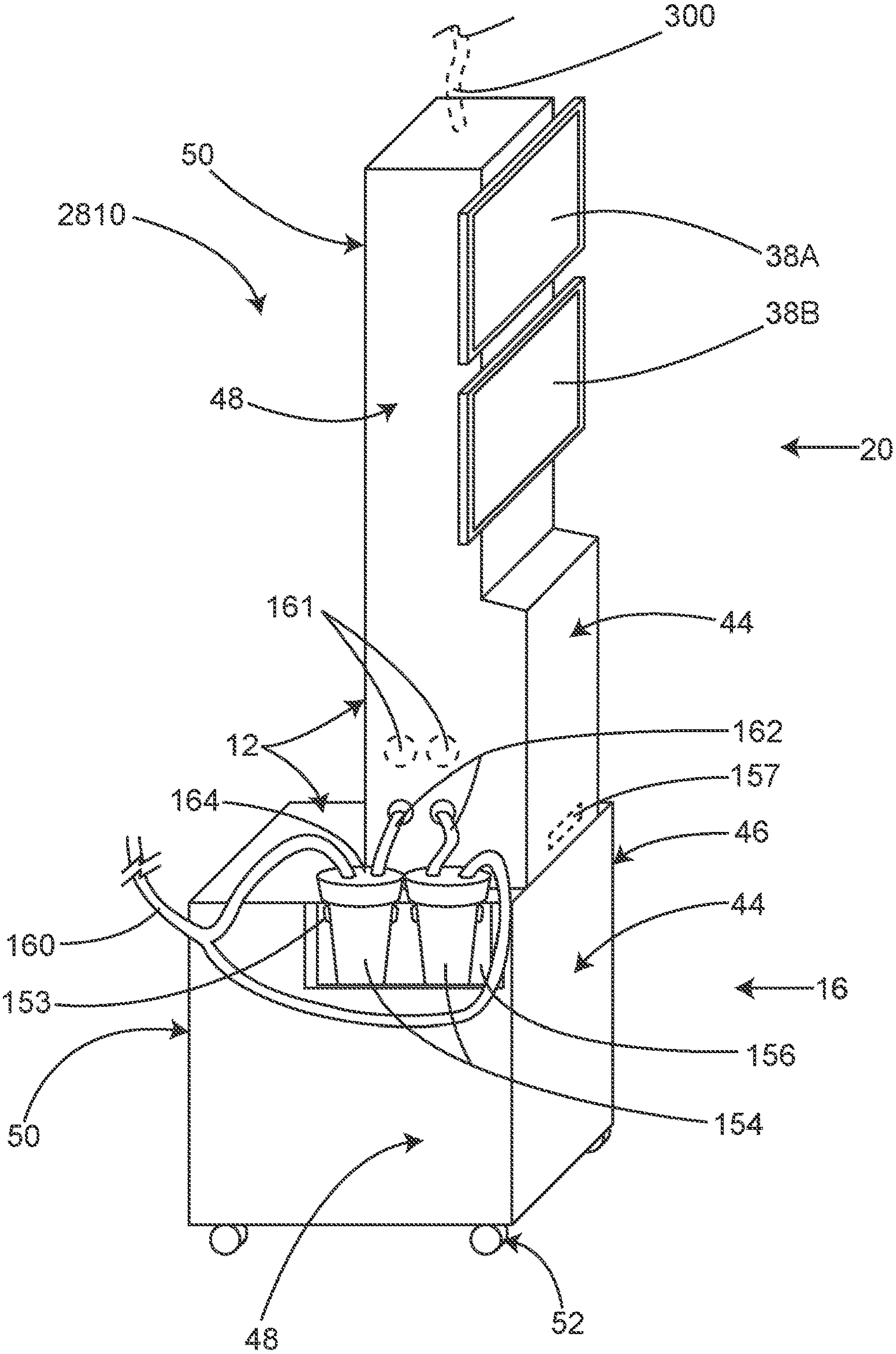

300
50
2810
38A
38B
48
20
44
161
162
12
157
164
46
44
160
153
16
156
50
154
48
52

Fig. 28

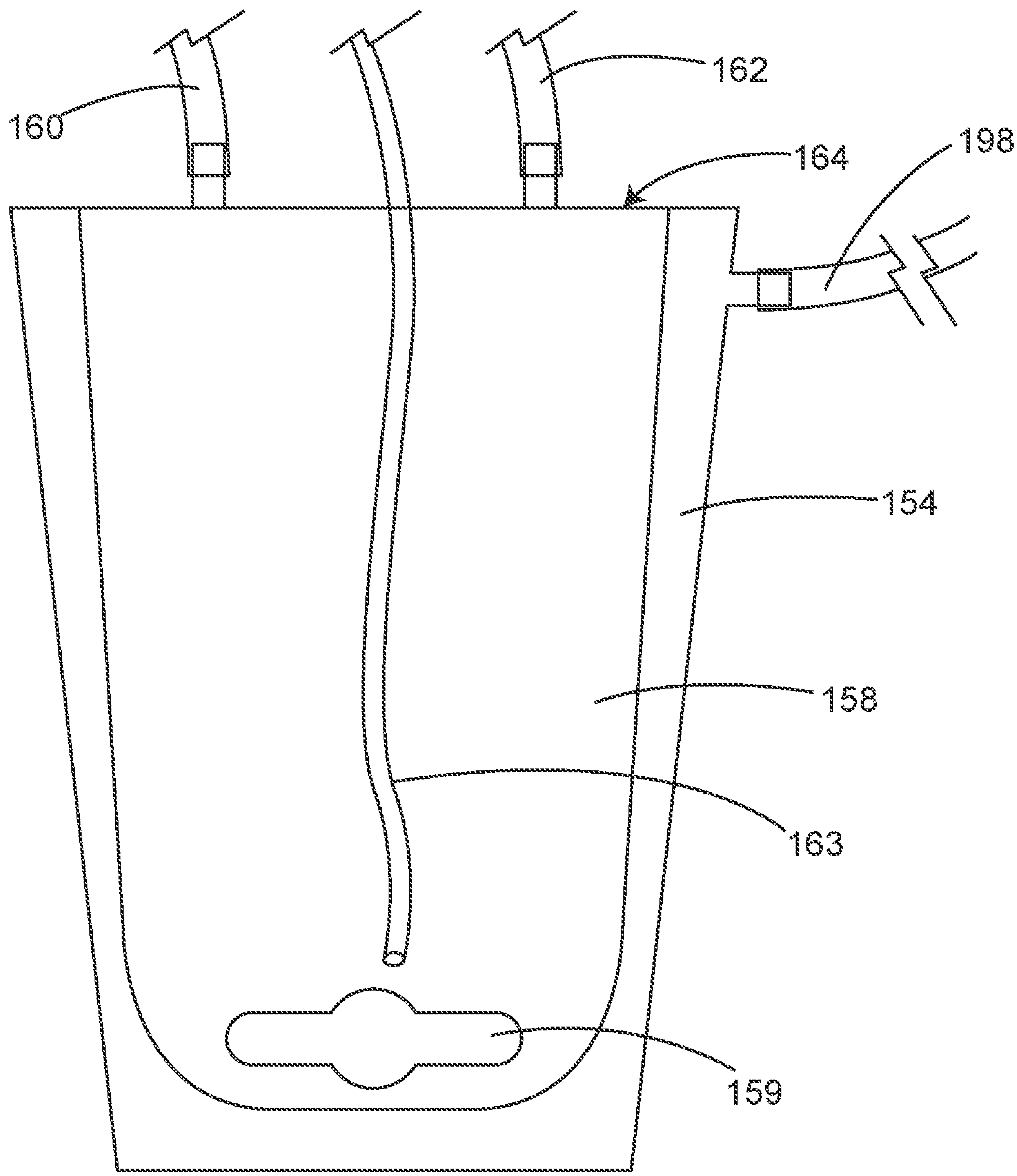


Fig. 29

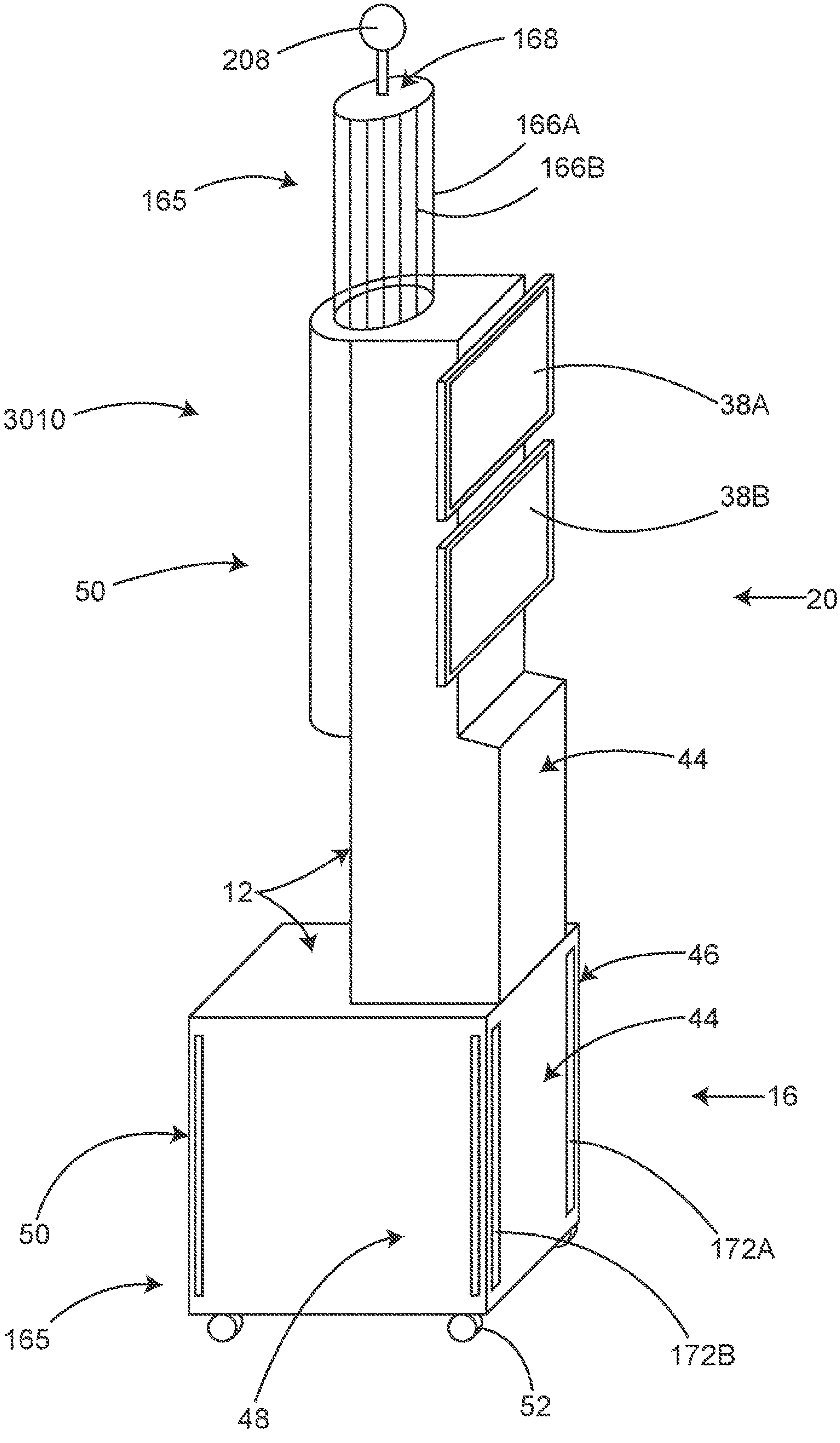

208
168
166A
166B
165
3010
38A
38B
50
20
44
12
46
44
16
50
172A
165
172B
48
52

Fig. 30

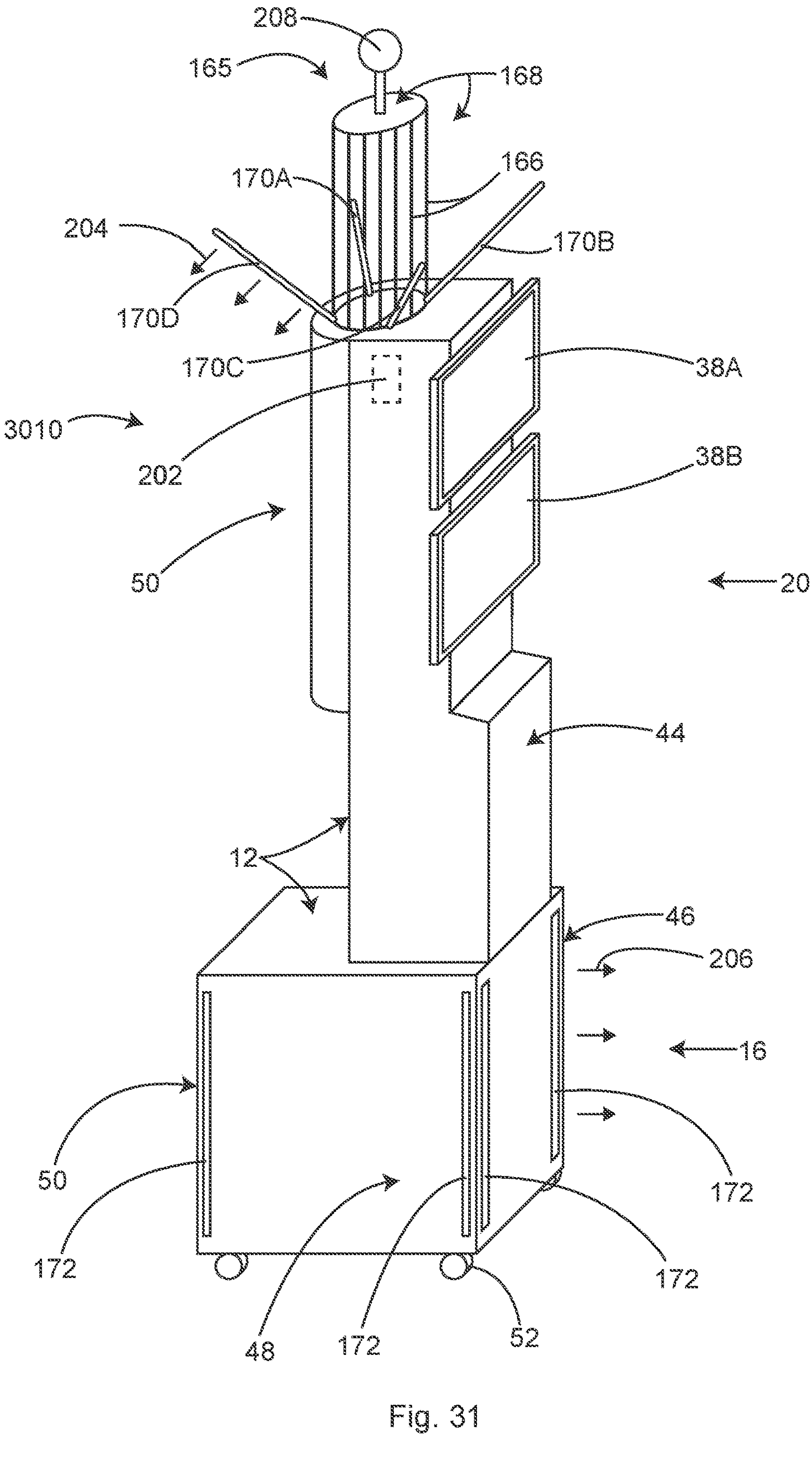

208
165
168
166
170A
204
170B
170D
170C
38A
3010
202
38B
50
20
44
12
46
206
16
50
172
172
172
48
172
52

Fig. 31

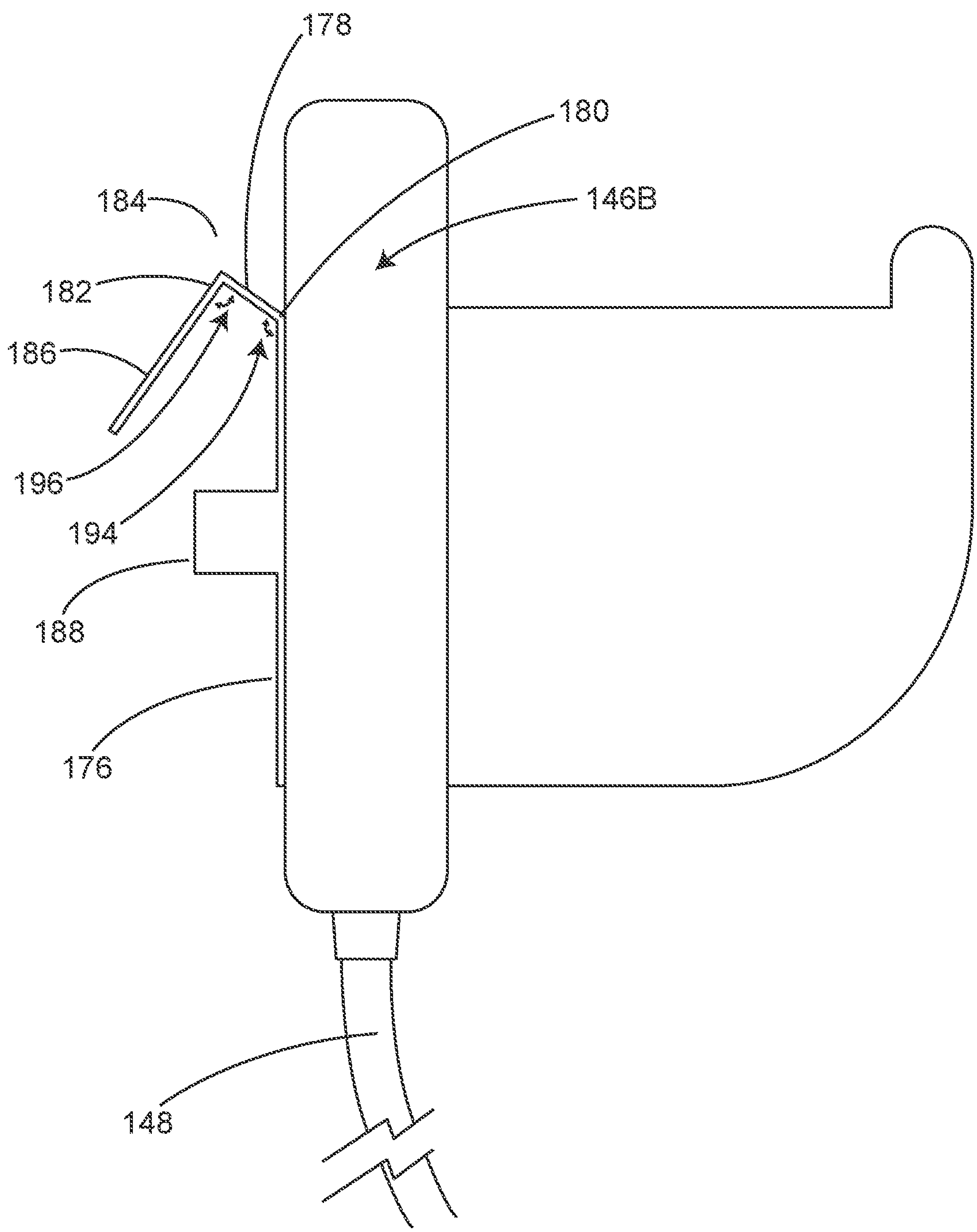


Fig. 32A

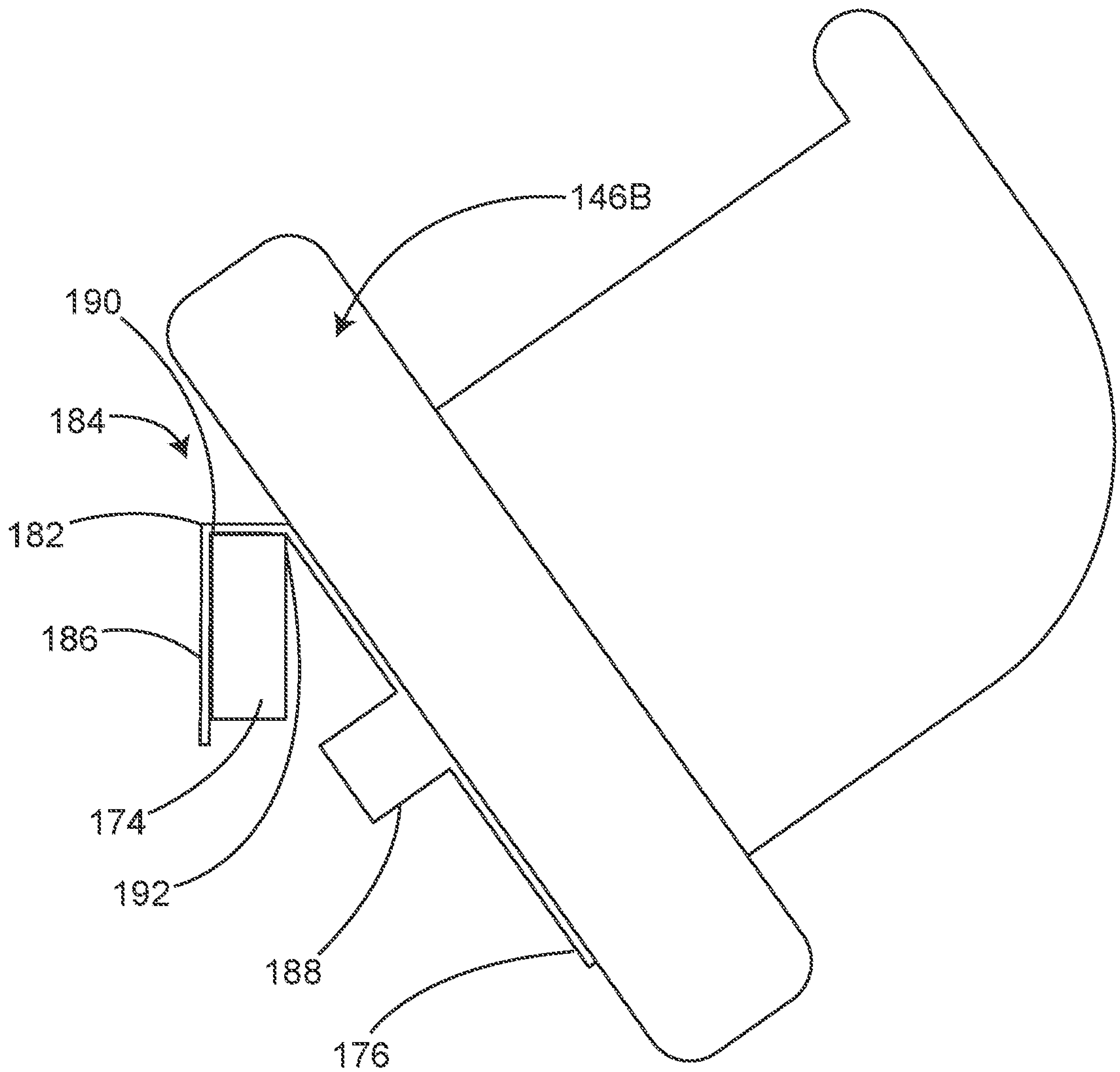


Fig. 32B

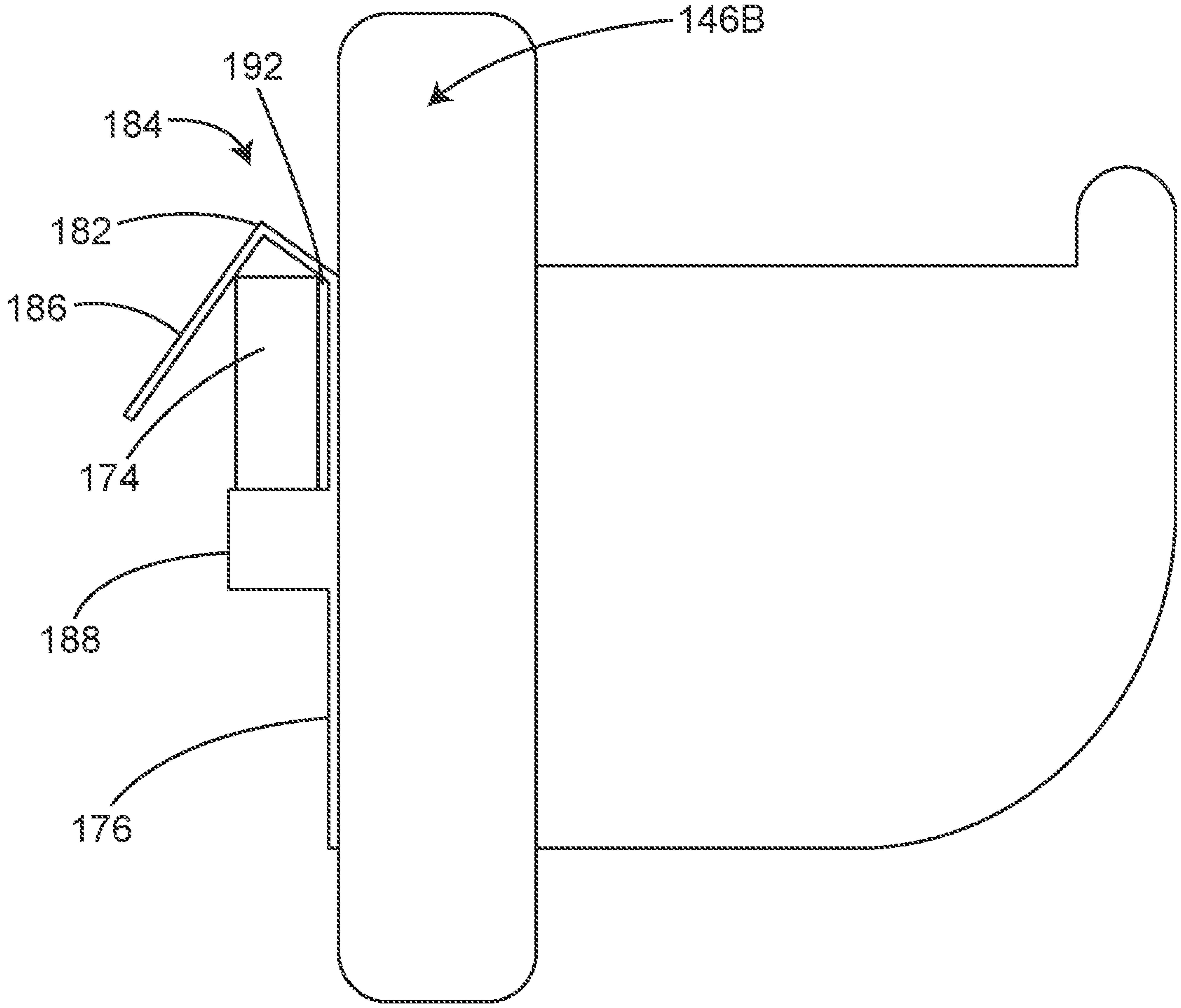


Fig. 32C

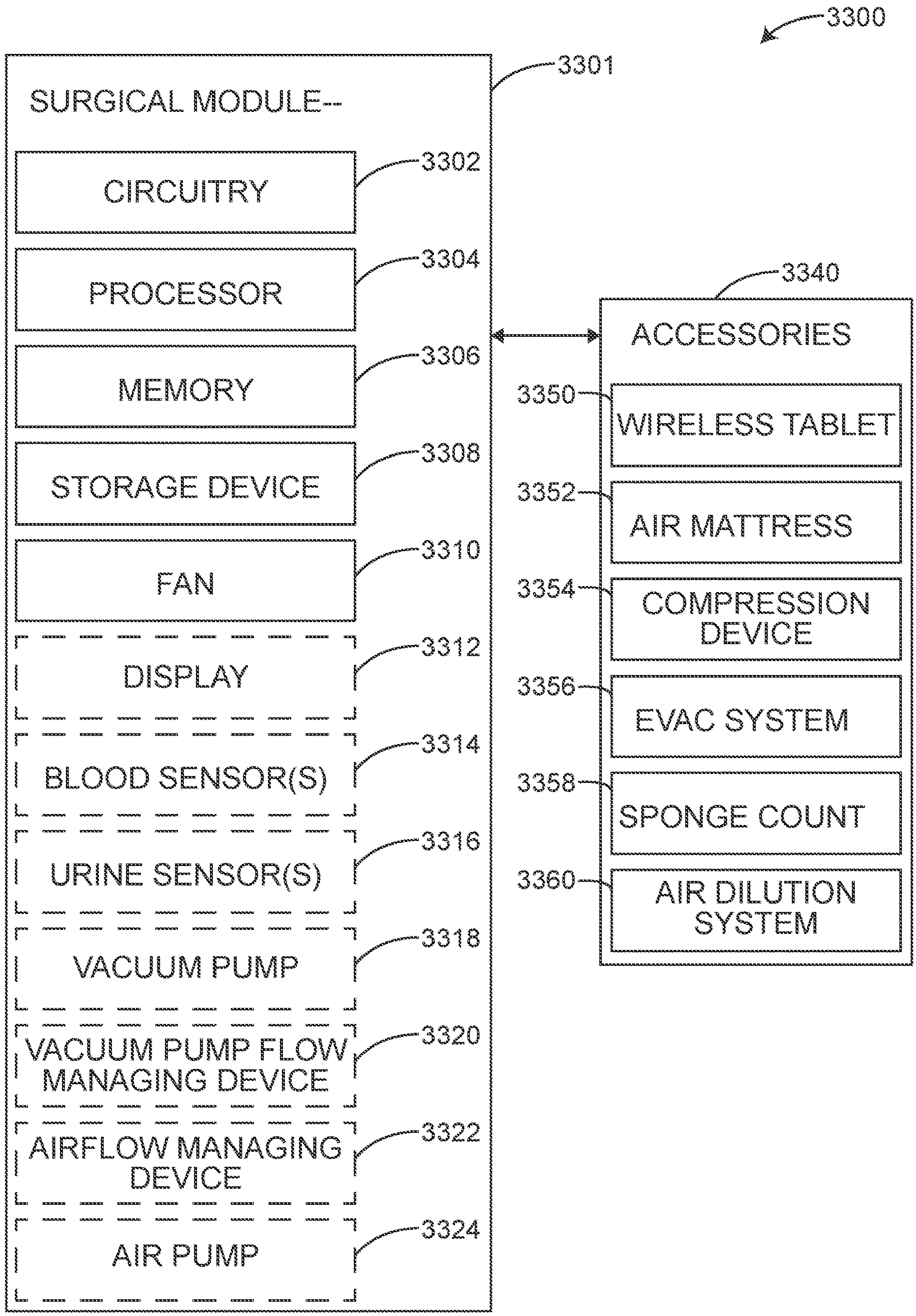

3300
3301
SURGICAL MODULE--
CIRCUITRY
3302
PROCESSOR
3304
MEMORY
3306
STORAGE DEVICE
3308
FAN
3310
DISPLAY
3312
BLOOD SENSOR(S)
3314
URINE SENSOR(S)
3316
VACUUM PUMP
3318
VACUUM PUMP FLOW MANAGING DEVICE
3320
AIRFLOW MANAGING DEVICE
3322
AIR PUMP
3324
3340
ACCESSORIES
3350
WIRELESS TABLET
3352
AIR MATTRESS
3354
COMPRESSION DEVICE
3356
EVAC SYSTEM
3358
SPONGE COUNT
3360
AIR DILUTION SYSTEM

Fig. 33

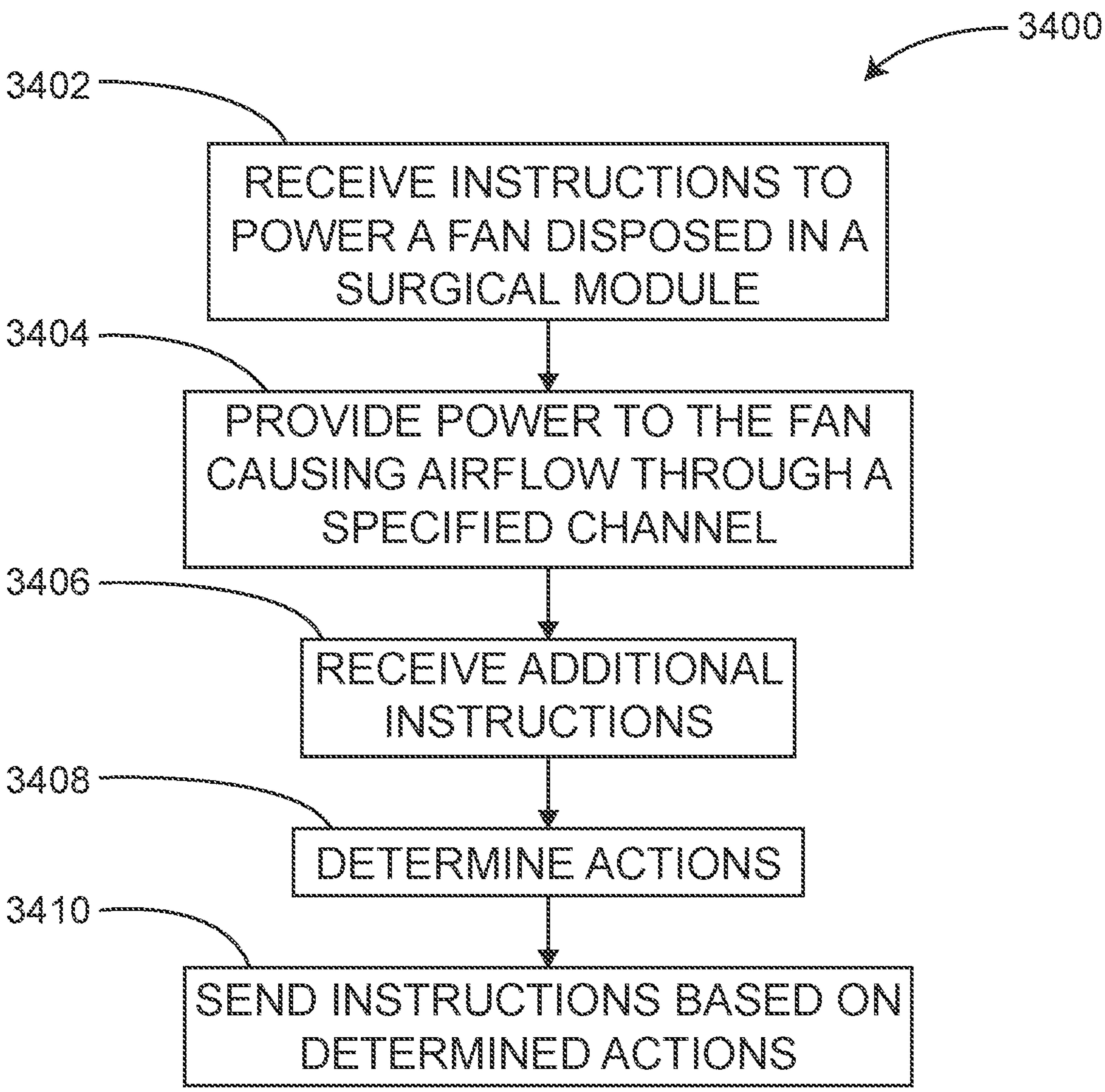

3400
3402
RECEIVE INSTRUCTIONS TO POWER A FAN DISPOSED IN A SURGICAL MODULE
3404
PROVIDE POWER TO THE FAN CAUSING AIRFLOW THROUGH A SPECIFIED CHANNEL
3406
RECEIVE ADDITIONAL INSTRUCTIONS
3408
DETERMINE ACTIONS
3410
SEND INSTRUCTIONS BASED ON DETERMINED ACTIONS

Fig. 34

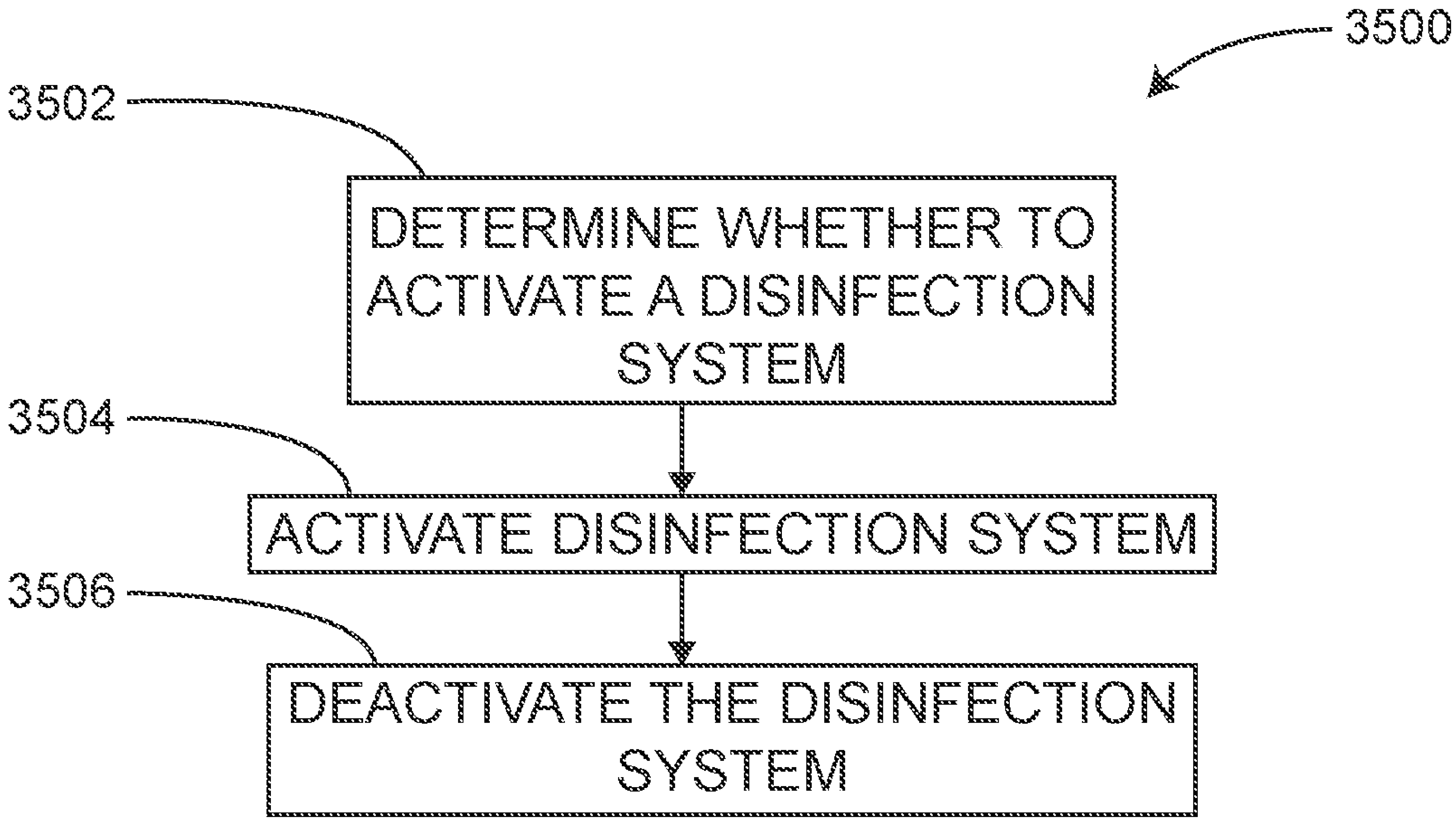

3500
3502
DETERMINE WHETHER TO ACTIVATE A DISINFECTION SYSTEM
3504
ACTIVATE DISINFECTION SYSTEM
3506
DEACTIVATE THE DISINFECTION SYSTEM

Fig. 35

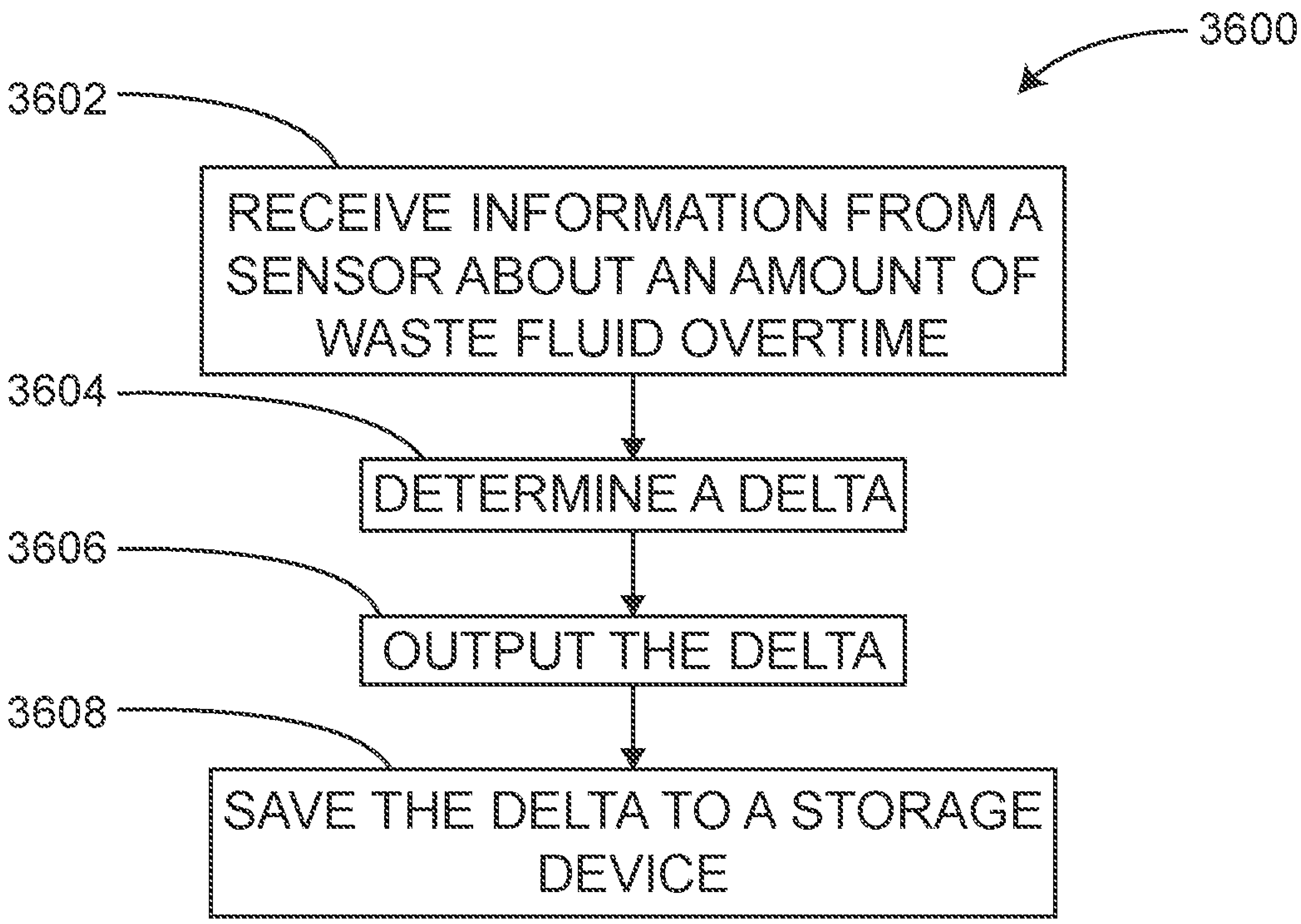

3600
3602
RECEIVE INFORMATION FROM A SENSOR ABOUT AN AMOUNT OF WASTE FLUID OVERTIME
3604
DETERMINE A DELTA
3606
OUTPUT THE DELTA
3608
SAVE THE DELTA TO A STORAGE DEVICE

Fig. 36

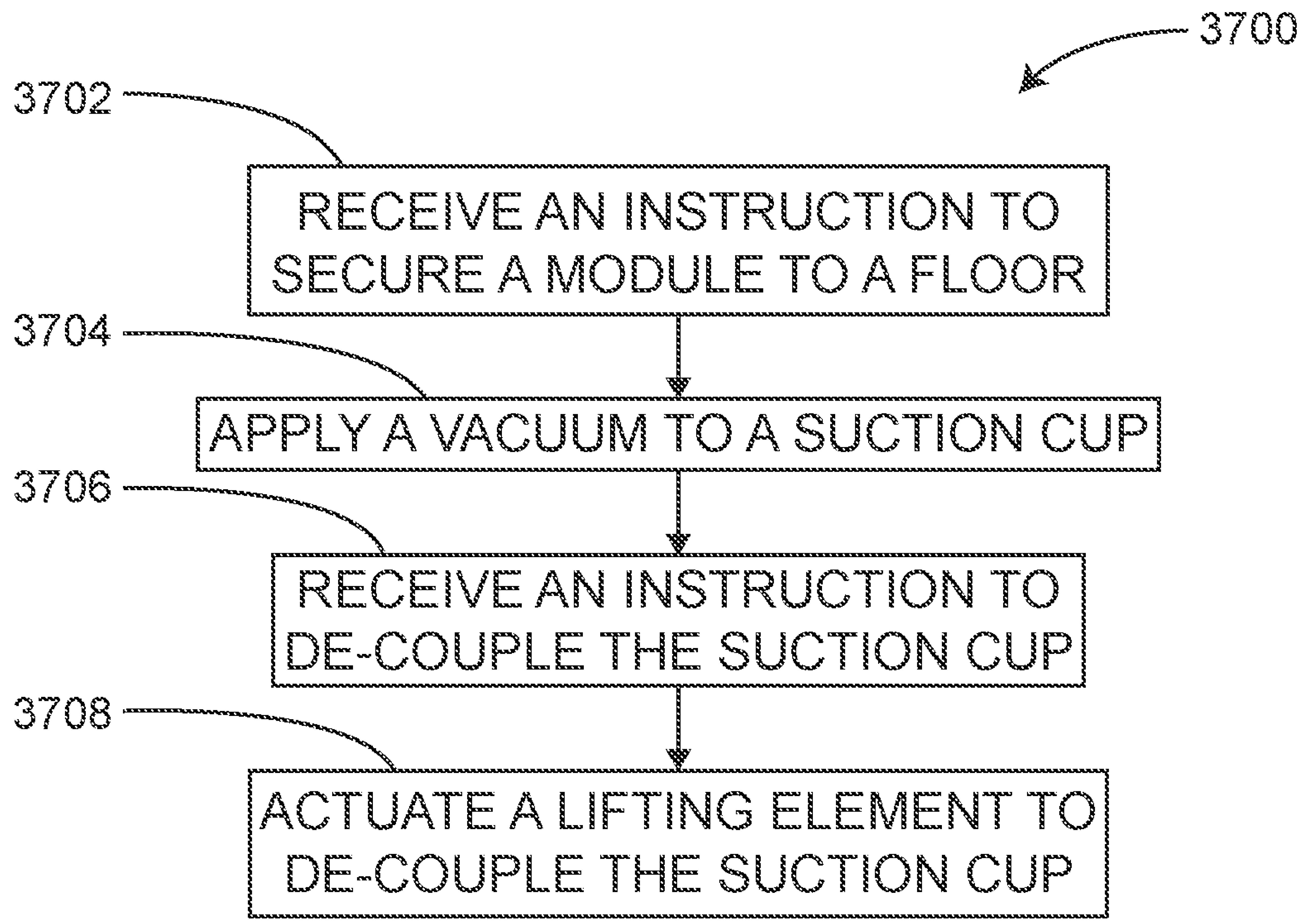

3700
3702
RECEIVE AN INSTRUCTION TO SECURE A MODULE TO A FLOOR
3704
APPLY A VACUUM TO A SUCTION CUP
3706
RECEIVE AN INSTRUCTION TO DE-COUPLE THE SUCTION CUP
3708
ACTUATE A LIFTING ELEMENT TO DE-COUPLE THE SUCTION CUP

Fig. 37

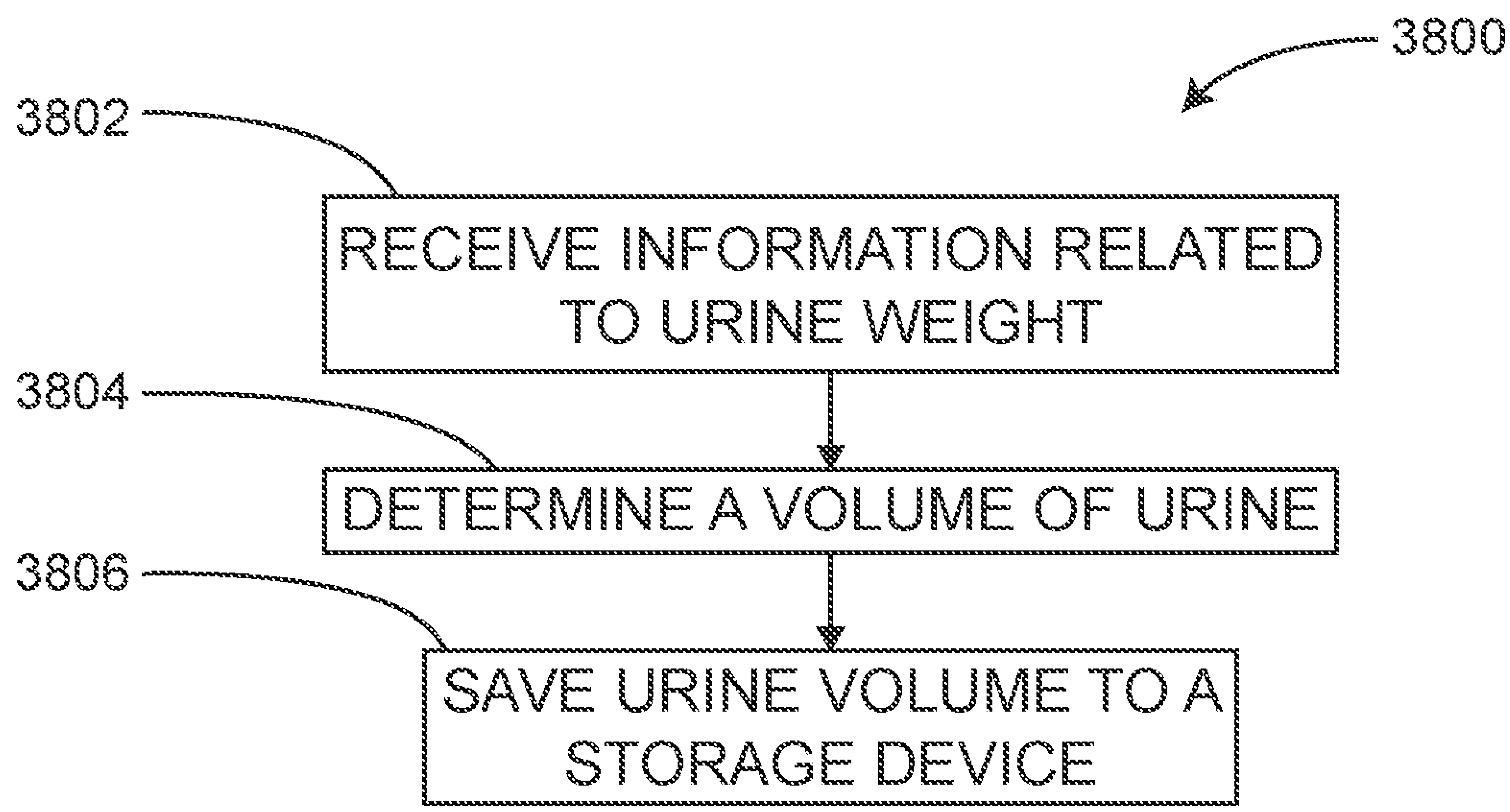

3800
3802
RECEIVE INFORMATION RELATED TO URINE WEIGHT
3804
DETERMINE A VOLUME OF URINE
3806
SAVE URINE VOLUME TO A STORAGE DEVICE

Fig. 38

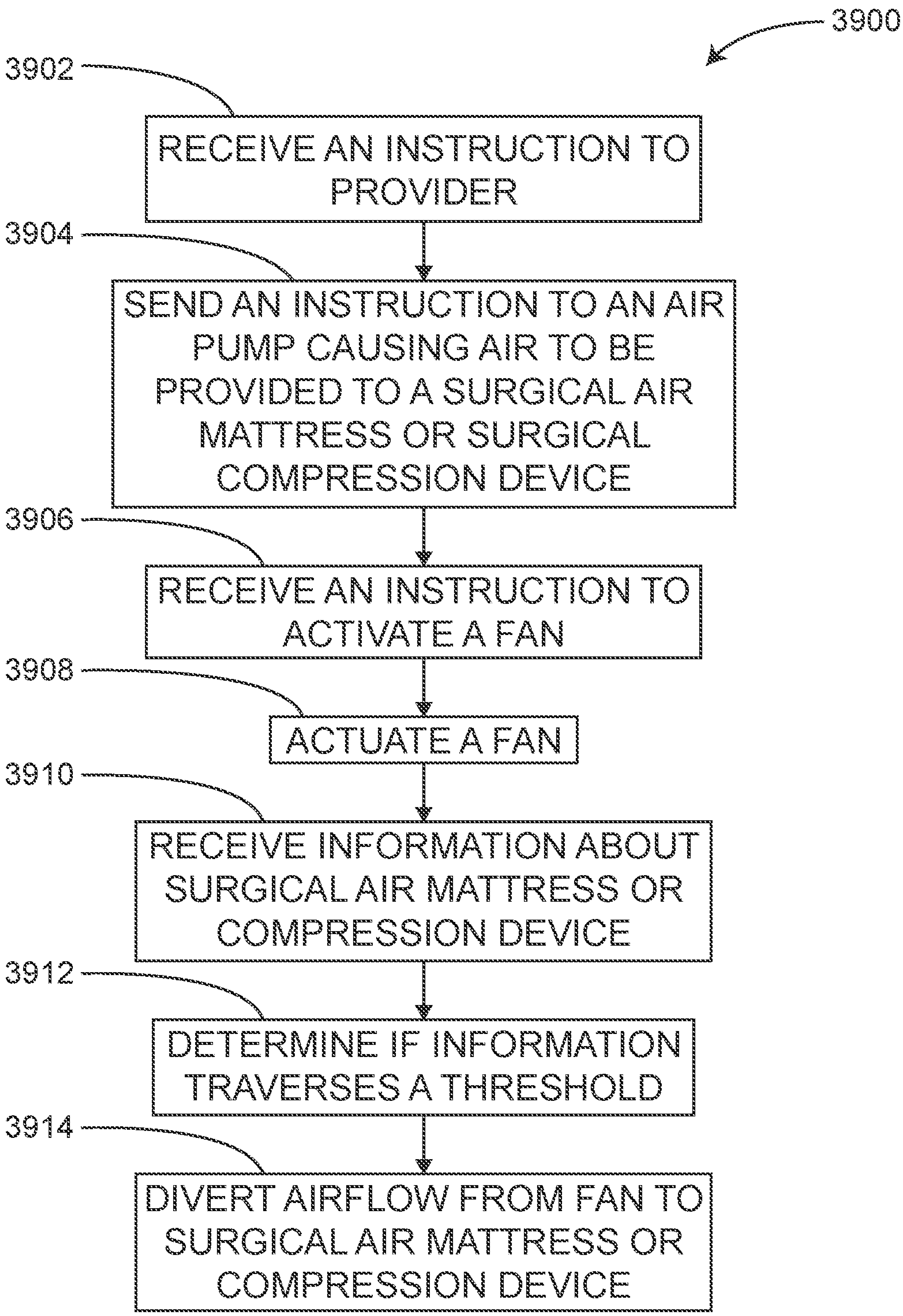

3900
3902
RECEIVE AN INSTRUCTION TO PROVIDER
3904
SEND AN INSTRUCTION TO AN AIR PUMP CAUSING AIR TO BE PROVIDED TO A SURGICAL AIR MATTRESS OR SURGICAL COMPRESSION DEVICE
3906
RECEIVE AN INSTRUCTION TO ACTIVATE A FAN
3908
ACTUATE A FAN
3910
RECEIVE INFORMATION ABOUT SURGICAL AIR MATTRESS OR COMPRESSION DEVICE
3912
DETERMINE IF INFORMATION TRAVERSES A THRESHOLD
3914
DIVERT AIRFLOW FROM FAN TO SURGICAL AIR MATTRESS OR COMPRESSION DEVICE

Fig. 39

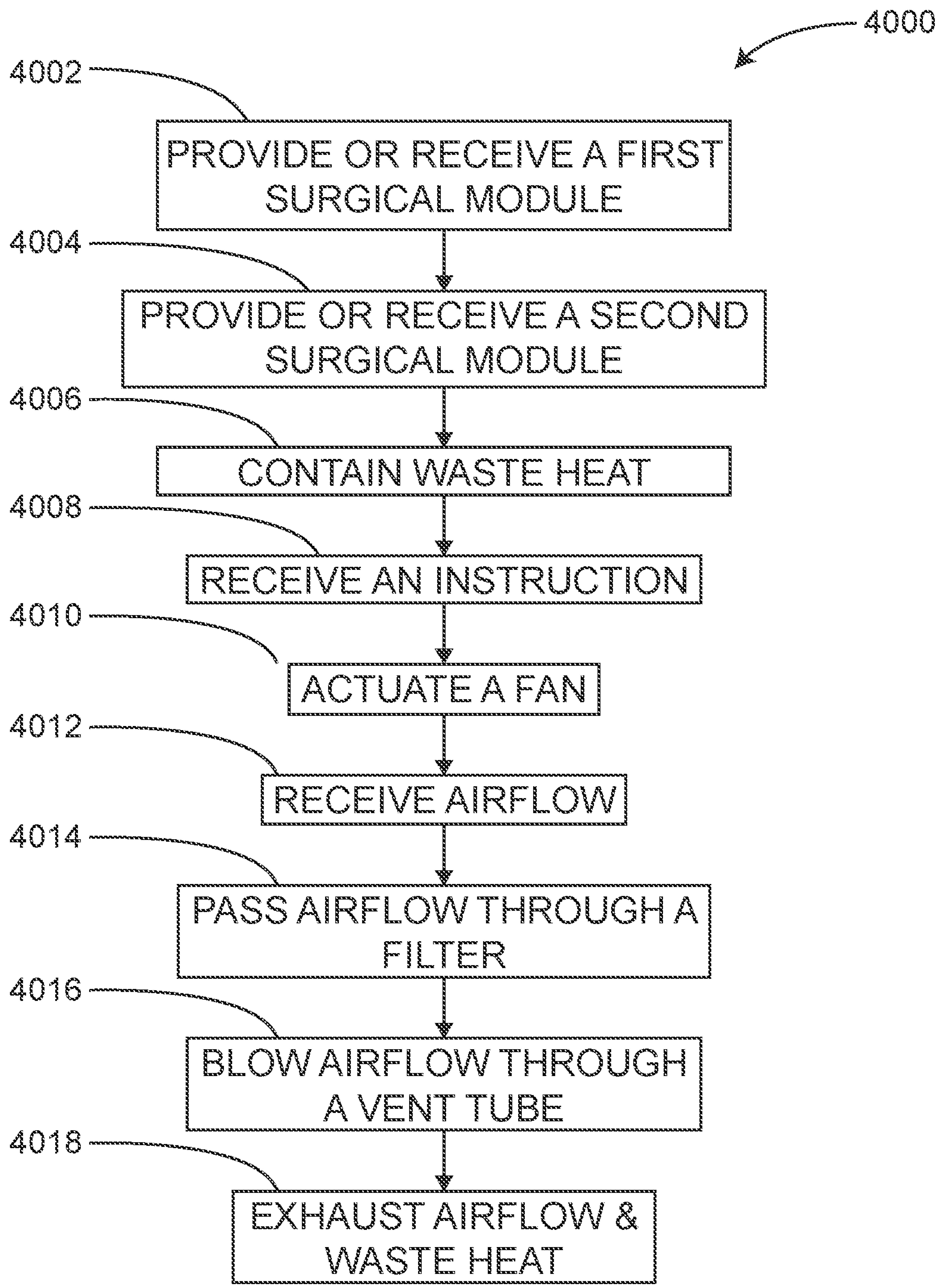

4000
4002
PROVIDE OR RECEIVE A FIRST SURGICAL MODULE
4004
PROVIDE OR RECEIVE A SECOND SURGICAL MODULE
4006
CONTAIN WASTE HEAT
4008
RECEIVE AN INSTRUCTION
4010
ACTUATE A FAN
4012
RECEIVE AIRFLOW
4014
PASS AIRFLOW THROUGH A FILTER
4016
BLOW AIRFLOW THROUGH A VENT TUBE
4018
EXHAUST AIRFLOW & WASTE HEAT

Fig. 40

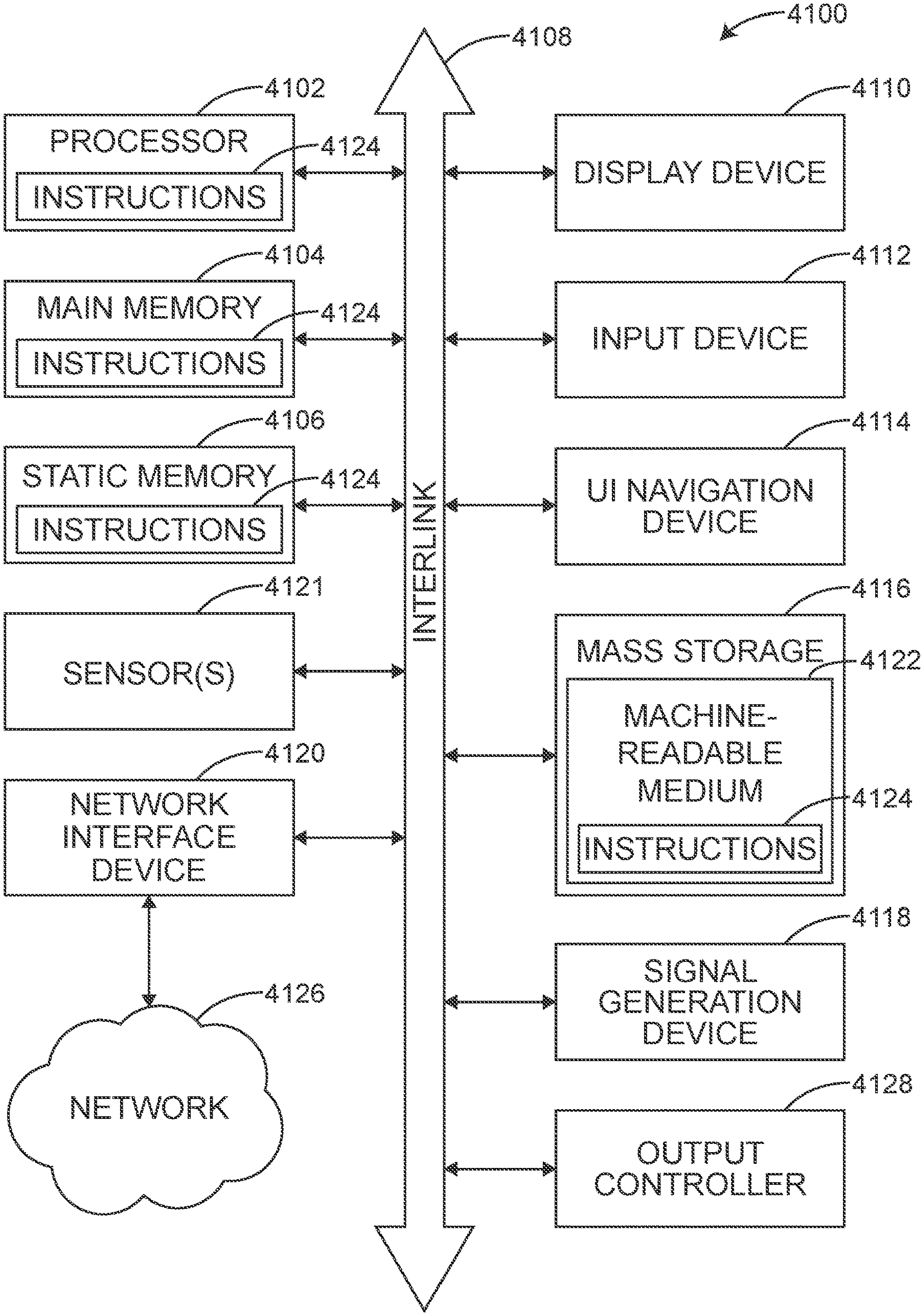

4100
4108
4102
PROCESSOR
4124
INSTRUCTIONS
4104
MAIN MEMORY
4124
INSTRUCTIONS
4106
STATIC MEMORY
4124
INSTRUCTIONS
4121
SENSOR(S)
4120
NETWORK INTERFACE DEVICE
4126
NETWORK
INTERLINK
4110
DISPLAY DEVICE
4112
INPUT DEVICE
4114
UI NAVIGATION DEVICE
4116
MASS STORAGE
4122
MACHINE-READABLE MEDIUM
4124
INSTRUCTIONS
4118
SIGNAL GENERATION DEVICE
4128
OUTPUT CONTROLLER

Fig. 41

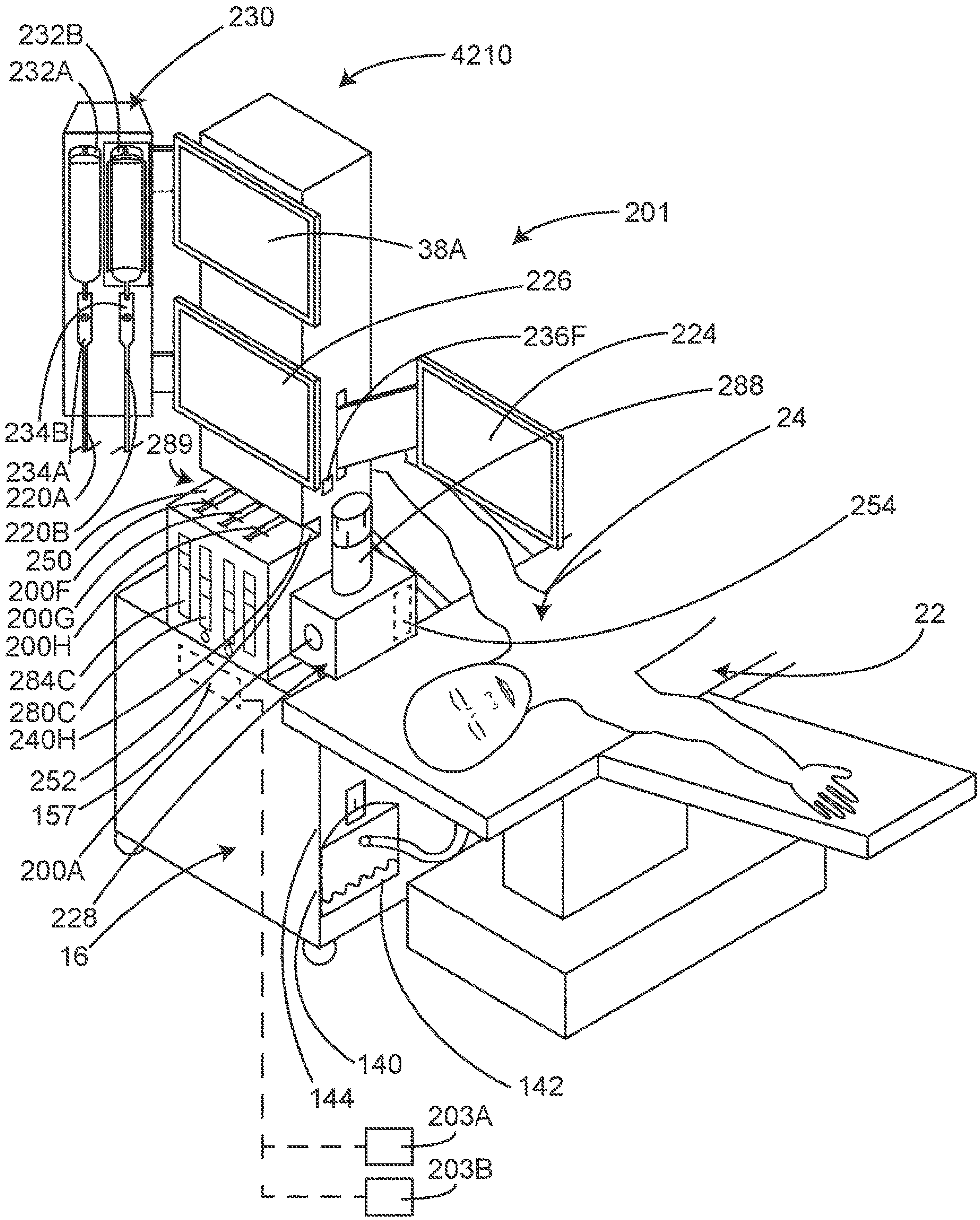

230
232B
232A
4210
201
38A
226
236F
224
288
24
254
22
234B
234A
289
220A
220B
250
200F
200G
200H
284C
280C
240H
252
157
200A
228
16
140
144
142
203A
203B

Fig. 42

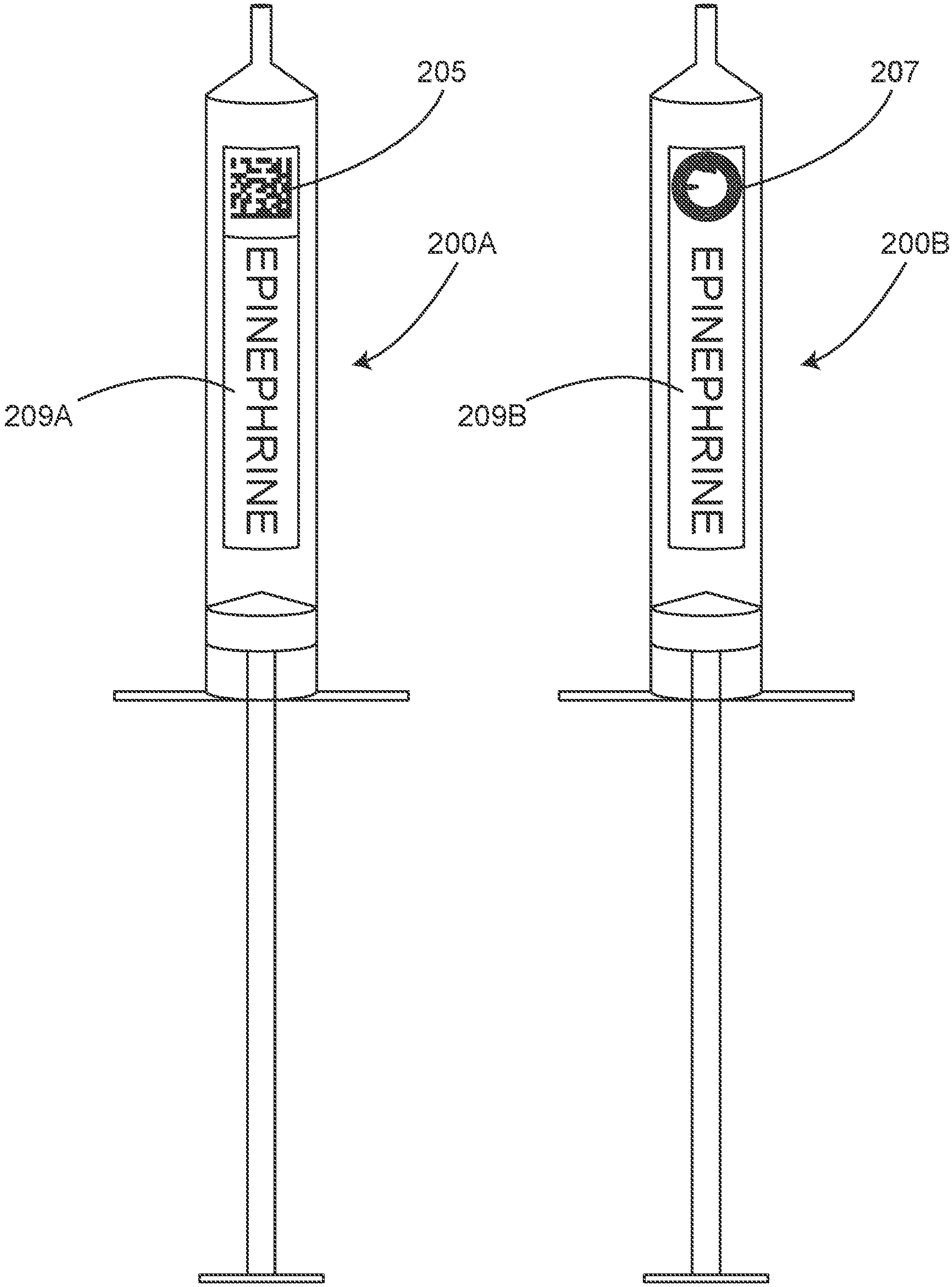


Fig. 43

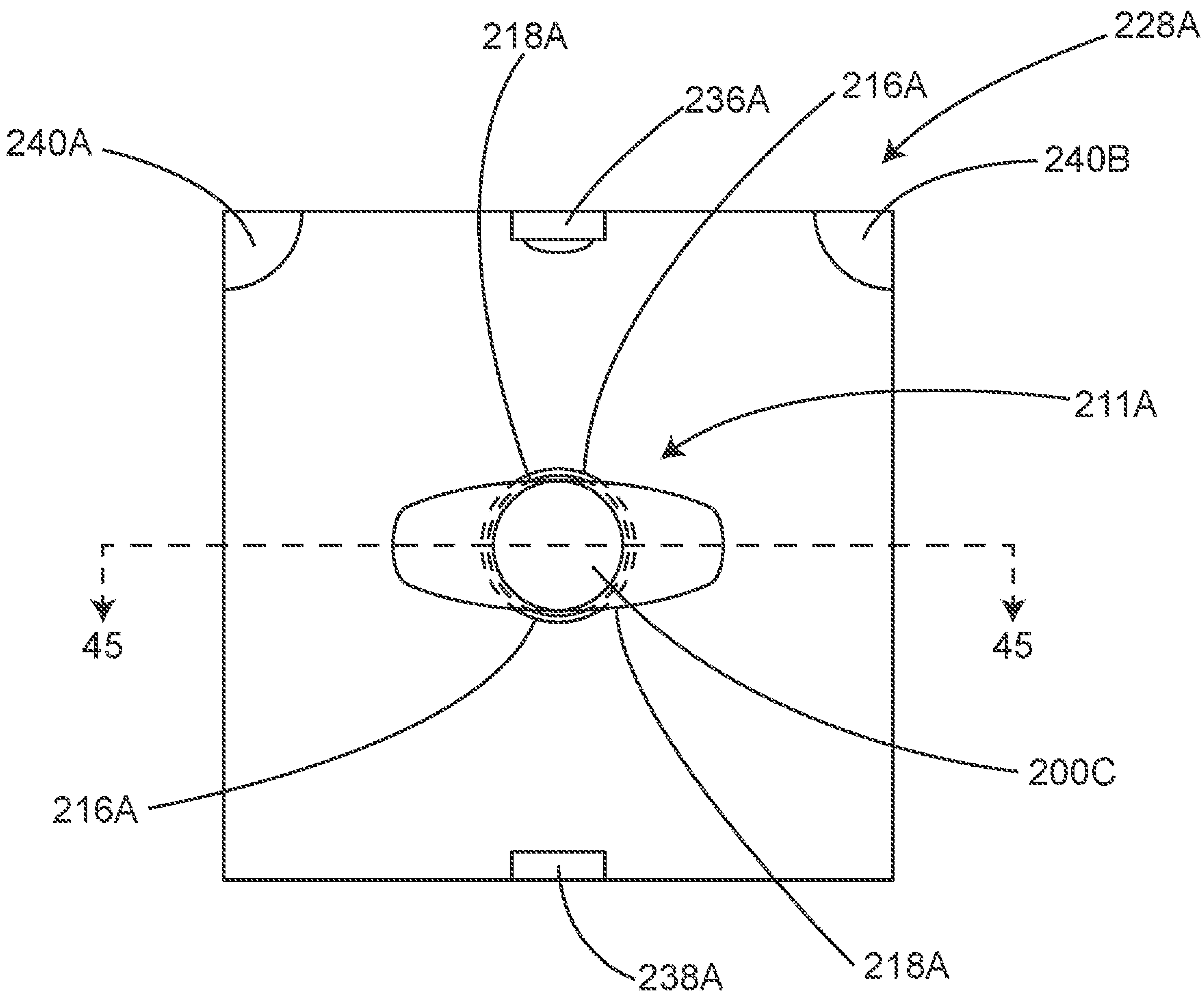


Fig. 44

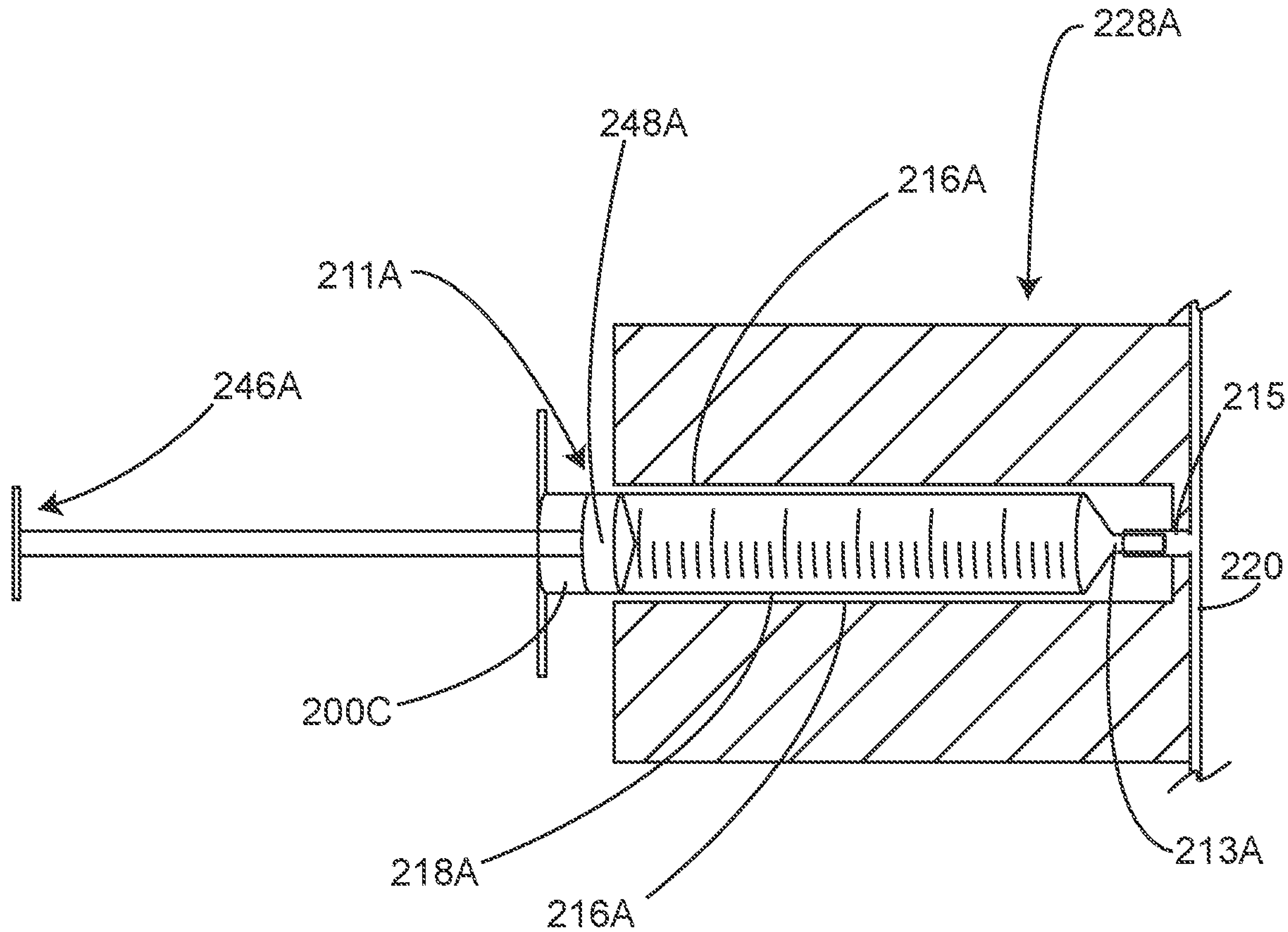
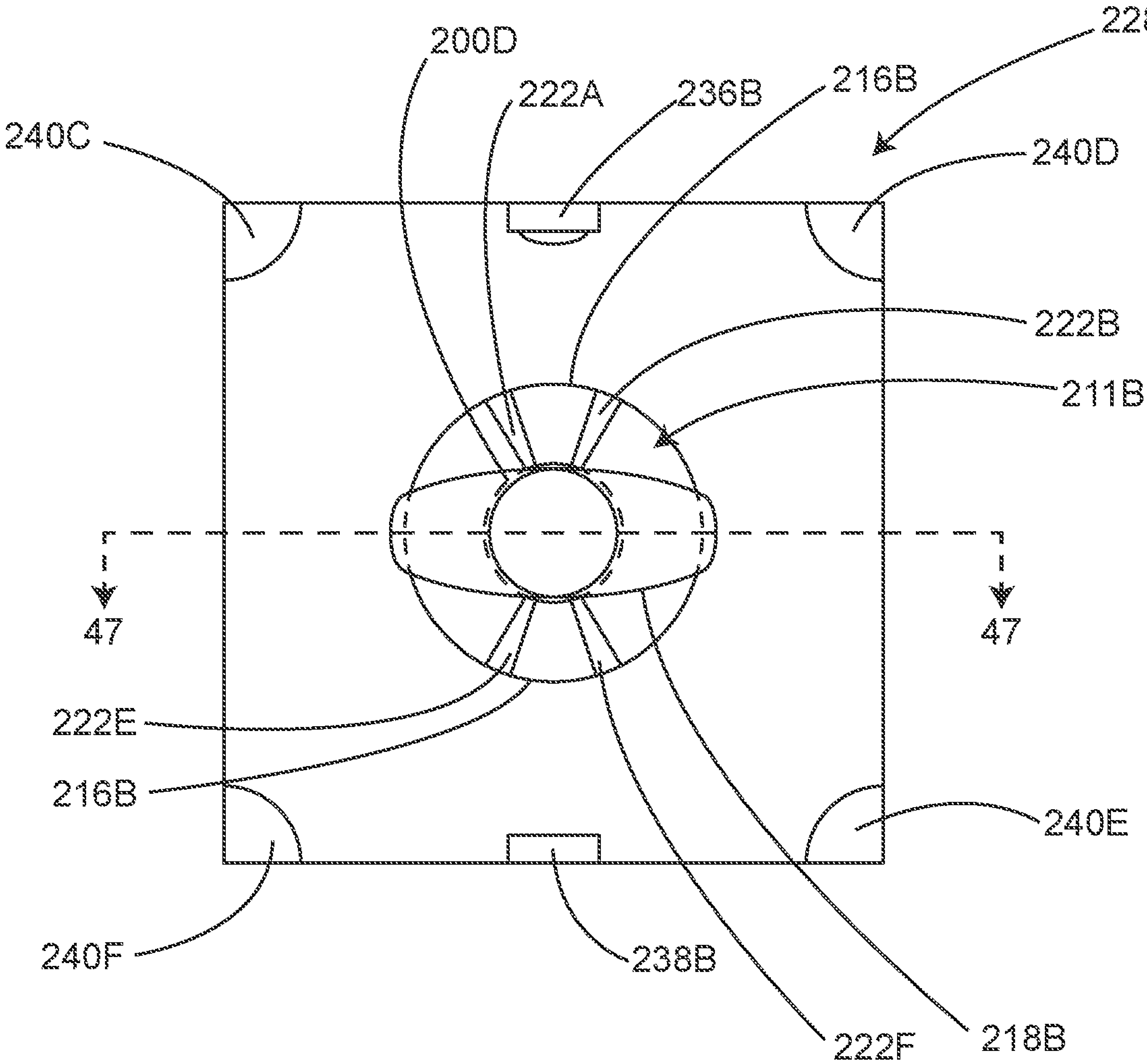


Fig. 45



200D
222A
236B
216B
228B
240C
240D
222B
211B
47
47
222E
216B
240E
240F
238B
222F
218B

Fig. 46

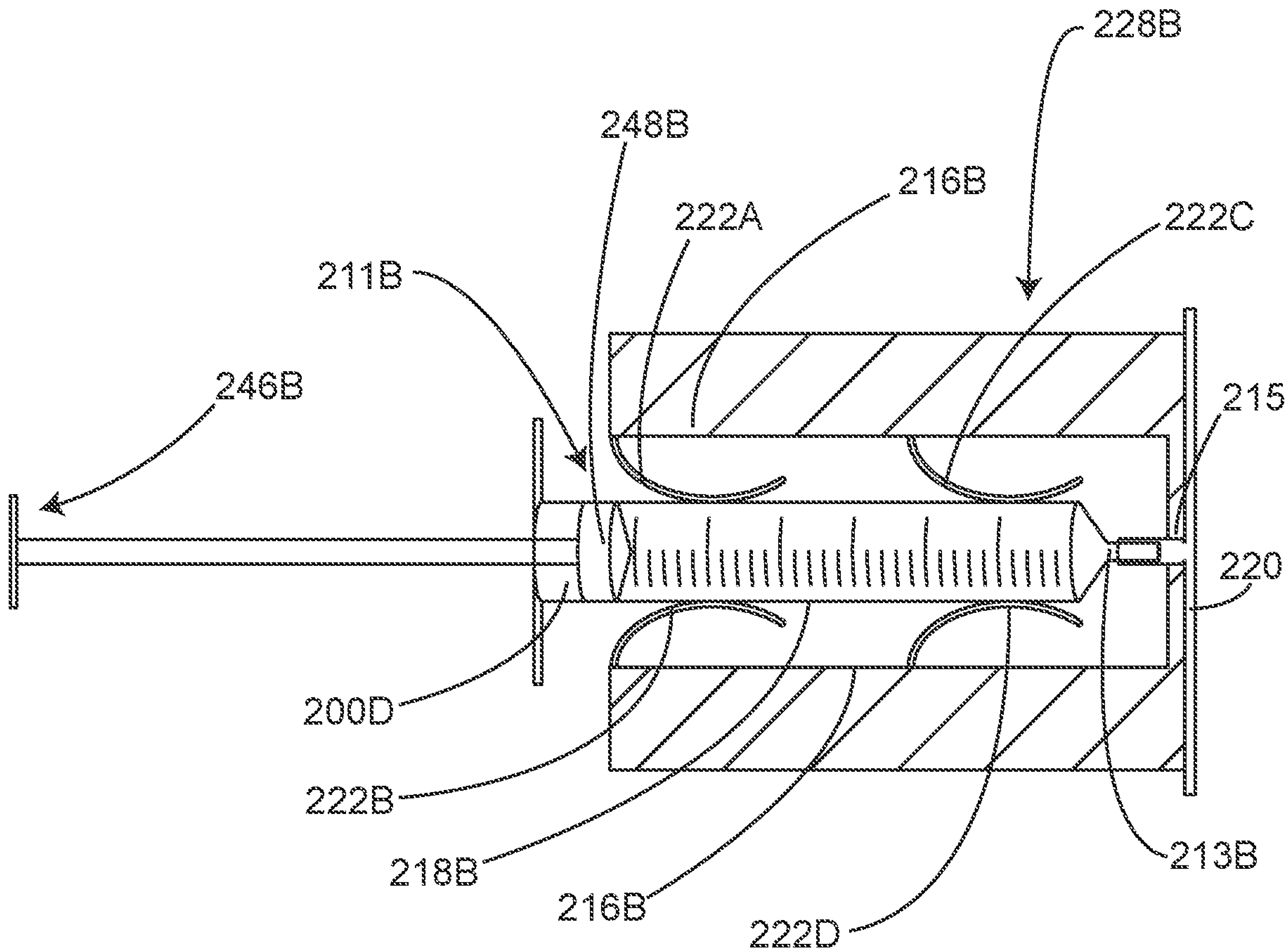

228B
248B
216B
222A
222C
211B
246B
215
220
200D
222B
218B
216B
222D
213B

Fig. 47

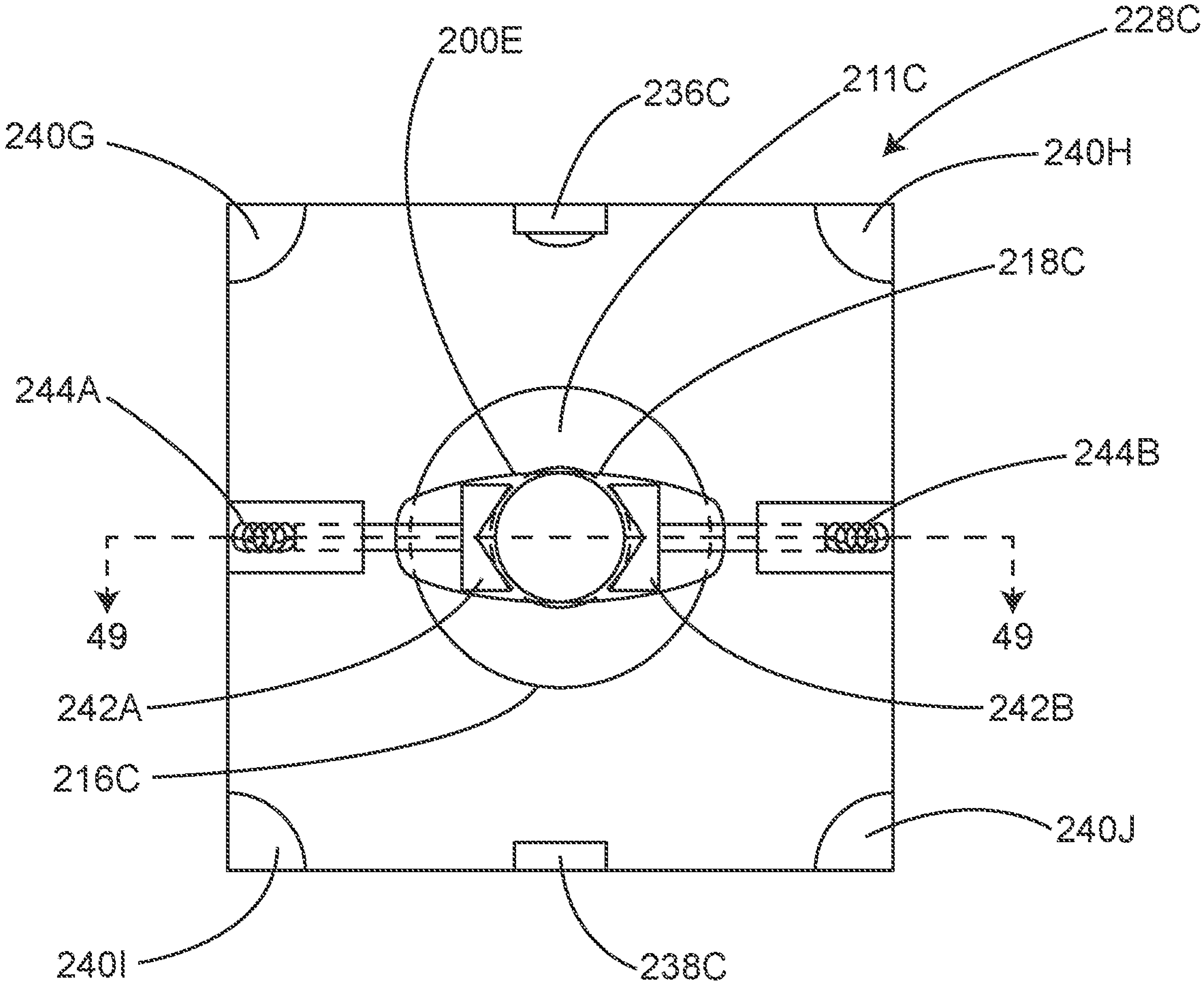

200E
228C
211C
236C
240G
240H
218C
244A
244B
49
49
242A
242B
216C
240J
240I
238C

Fig. 48

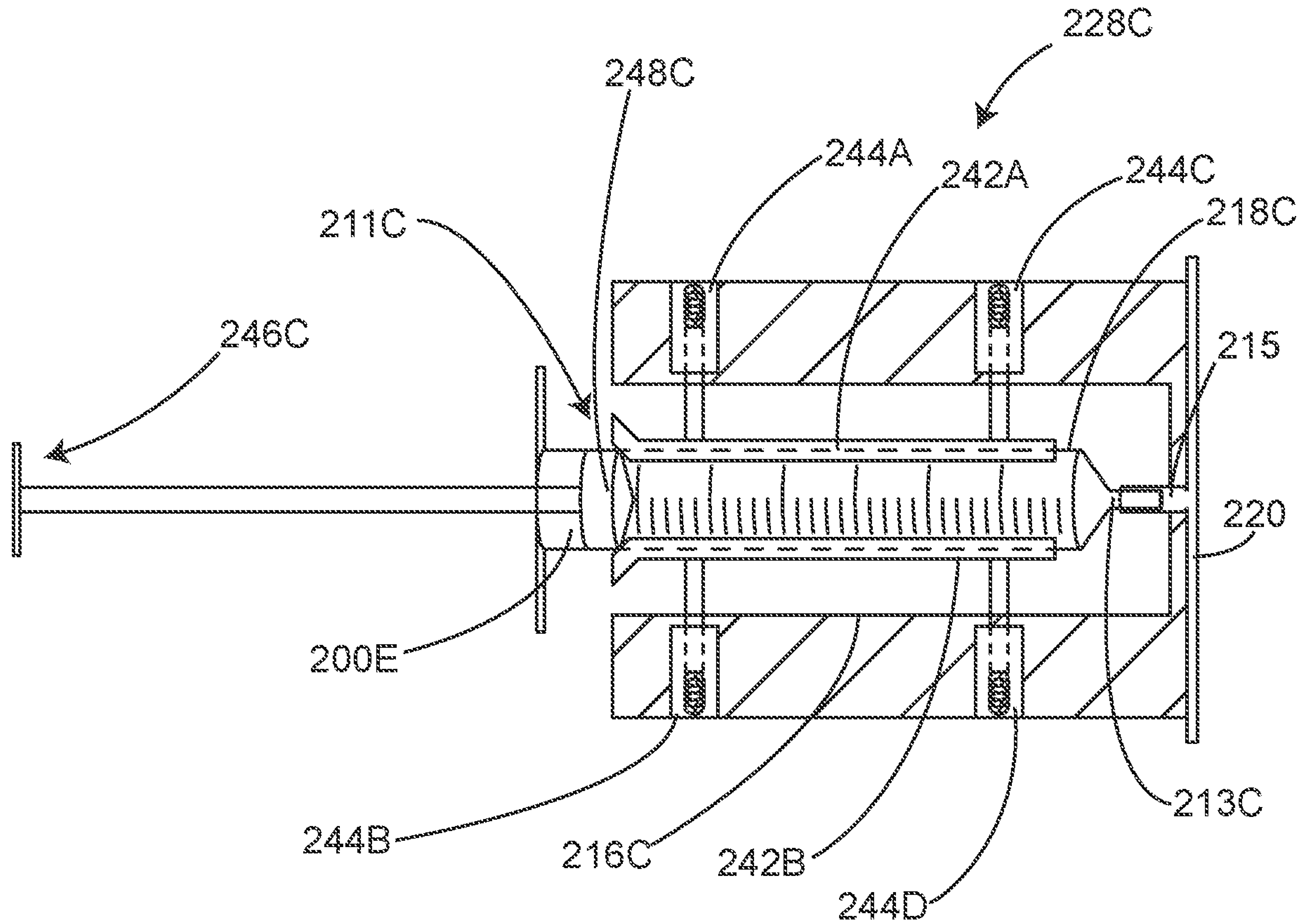

228C
248C
244A
242A
244C
218C
211C
215
246C
220
200E
244B
216C
242B
244D
213C

Fig. 49

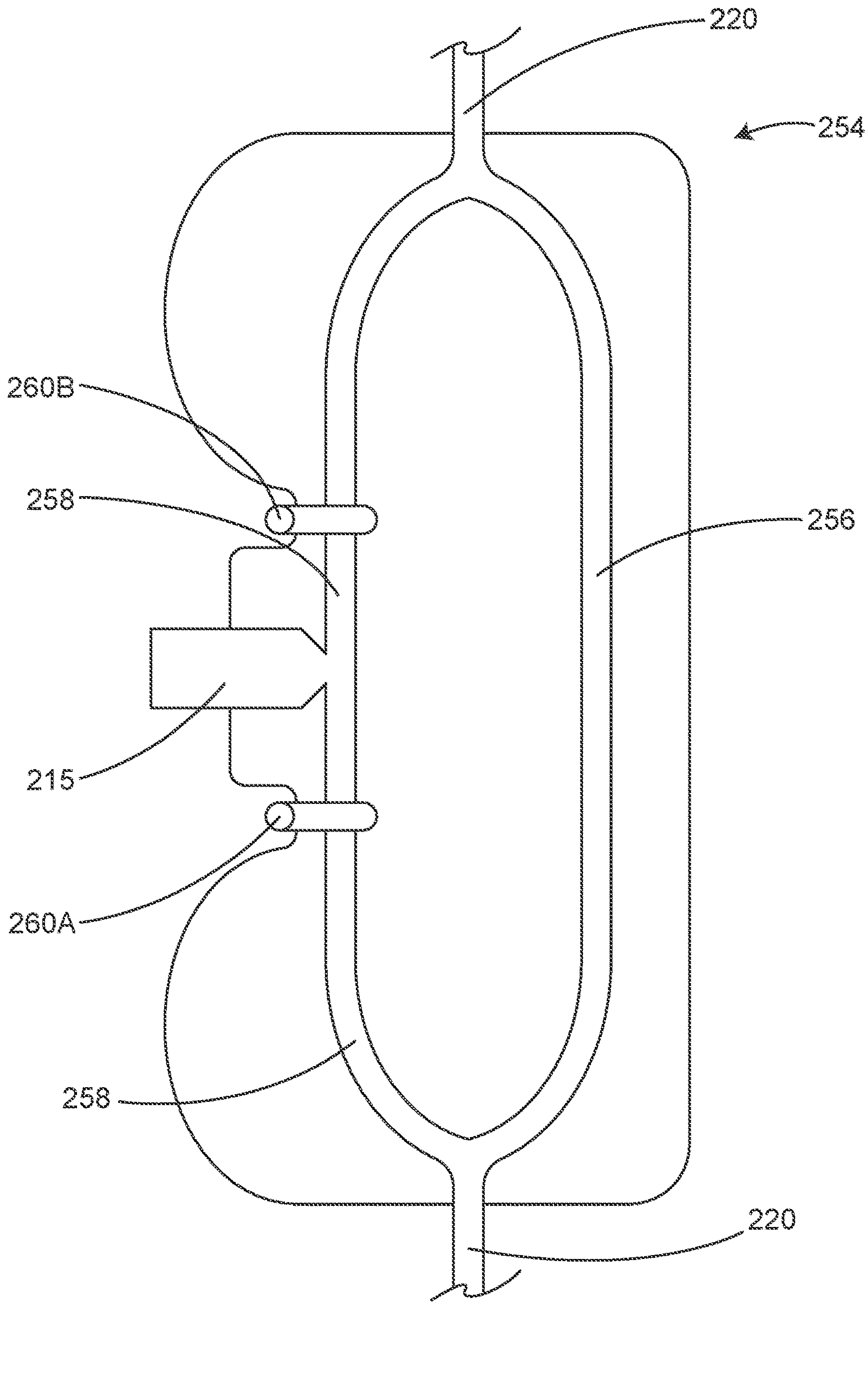
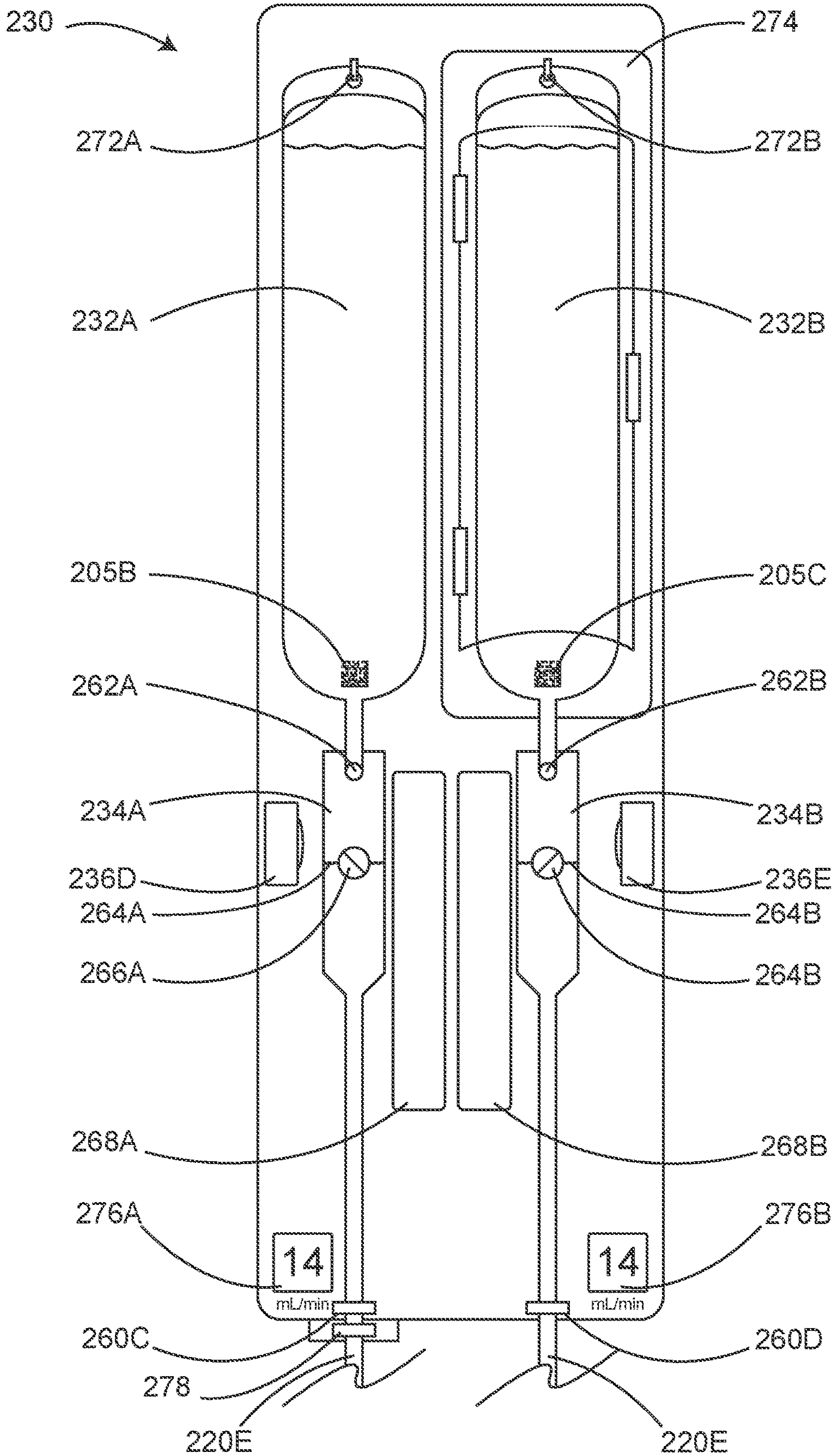


Fig. 50



230
274
272A
272B
232A
232B
205B
205C
262A
262B
234A
234B
236D
236E
264A
264B
266A
264B
268A
268B
276A
276B
14
mL/min
14
mL/min
260C
260D
278
220E
220E

Fig. 51

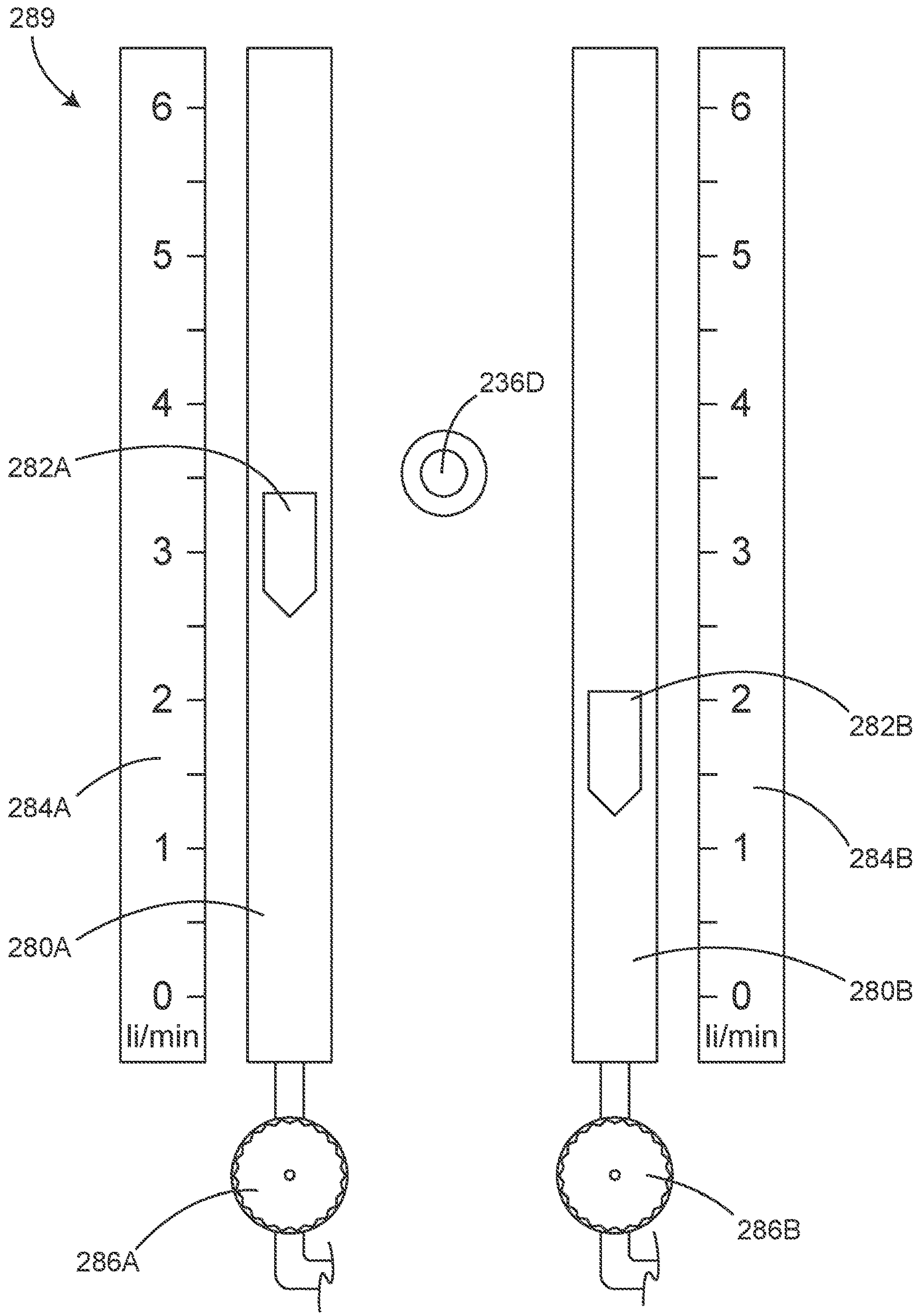

289
6
5
4
3
2
1
0
li/min
6
5
4
3
2
1
0
li/min
236D
282A
282B
284A
284B
280A
280B
286A
286B

Fig. 52

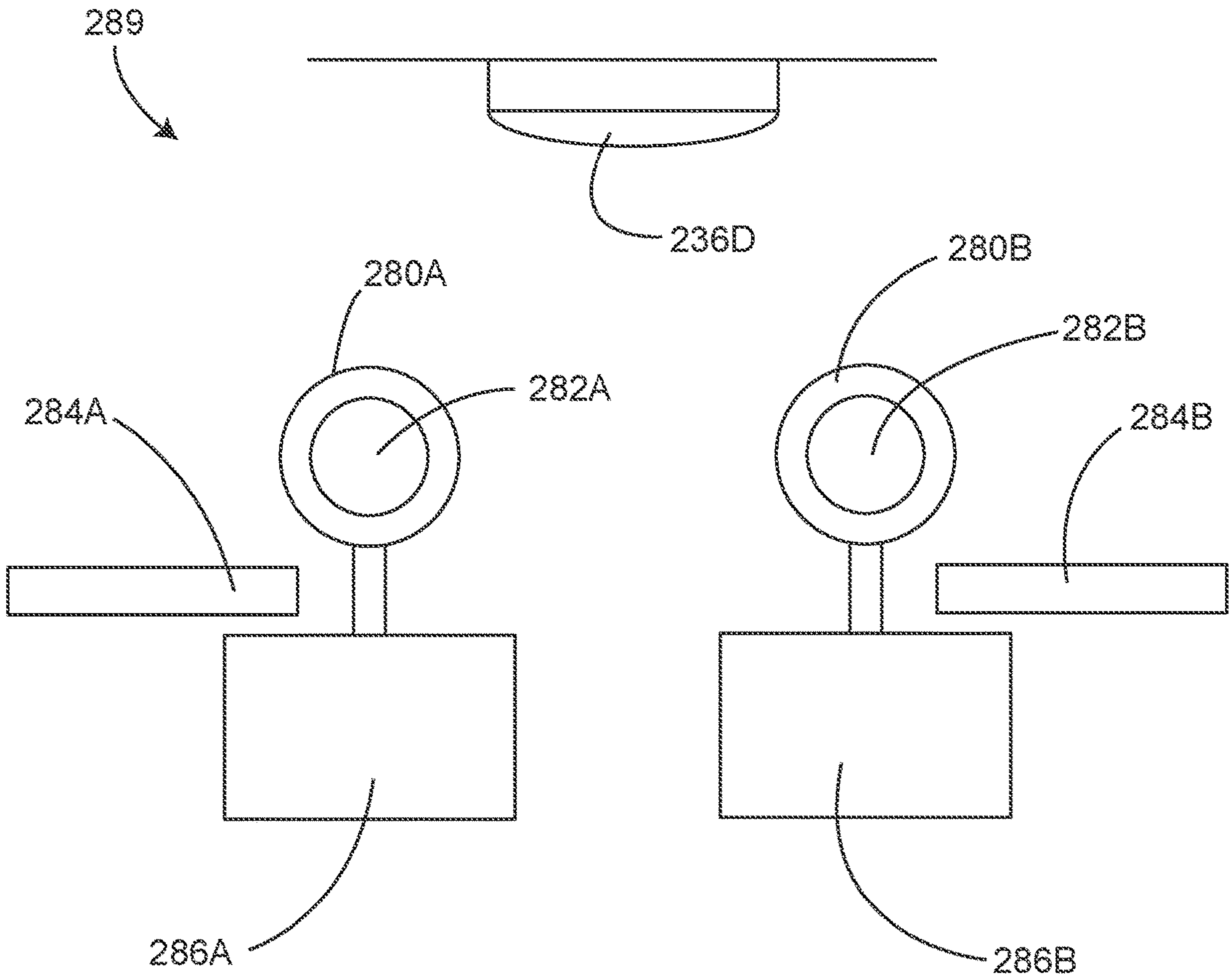


Fig. 53

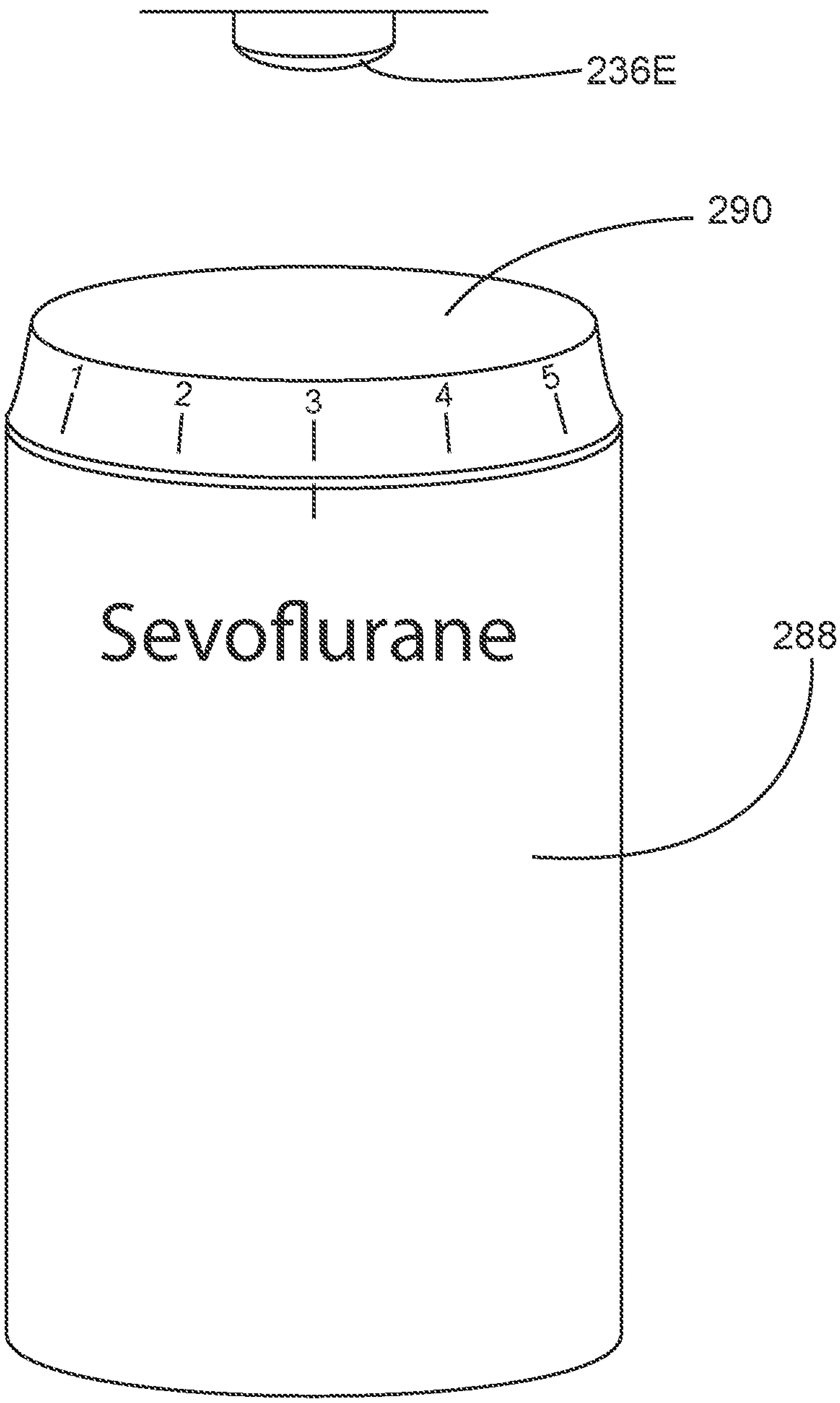


Fig. 54

RELOCATION MODULE AND METHODS FOR SURGICAL EQUIPMENT

PRIORITY

This application is a continuation of U.S. patent application Ser. No. 18/136,141, filed Apr. 18, 2023, which is a continuation of U.S. patent application Ser. No. 17/875,055, filed Jul. 27, 2022, now issued as U.S. Pat. No. 11,583,461, which is a continuation of U.S. patent application Ser. No. 17/697,398, filed Mar. 17, 2022, now issued as U.S. Pat. No. 11,523,960, which is a continuation of U.S. patent application Ser. No. 17/375,546, filed Jul. 14, 2021 now U.S. Pat. No. 11,291,602, which is a continuation of U.S. patent application Ser. No. 17/199,722, filed Mar. 12, 2021, now U.S. Pat. No. 11,173,089, which is a continuation of U.S. patent application Ser. No. 17/092,681, filed Nov. 9, 2020, now U.S. Patent No. 10,993,865, which is a continuation of U.S. patent application Ser. No. 16/879,406, filed May 20, 2020, now U.S. Pat. No. 10,869,800 B2, which is a continuation-in-part of U.S. patent application Ser. No. 16/601,924, filed Oct. 15, 2019, now U.S. Pat. No. 10,702,436 B2, which is a continuation of U.S. application Ser. No. 16/593,033, filed Oct. 4, 2019, now issued as U.S. Pat. No. 10,653,577, which is a continuation of U.S. patent application Ser. No. 16/364,884, filed Mar. 26, 2019, now issued as U.S. Pat. No. 10,507,153, which claims the benefit of priority to U.S. Provisional Patent Application 62/782,901, filed Dec. 20, 2018. U.S. patent application Ser. No. 16/364,884, filed Mar. 26, 2019, now issued as U.S. Patent No. 10,507,153 is also a continuation-in-part of U.S. patent application Ser. No. 15/935,524, filed Mar. 26, 2018, now issued as U.S. Pat. No. 10,512,191. The disclosures of all of these applications are incorporated herein by reference in their entirety.

TECHNICAL FIELD

This document pertains generally, but not by way of limitation, to systems and methods for improving safety in operating rooms. In particular, the systems and methods described herein may include but are not limited to, anesthetic equipment storage, waste air management, cable and hose management and automated anesthetic and patient monitoring data capture and electronic record input.

BACKGROUND

Anesthesia monitors and equipment as well as surgical equipment have been invented, developed and sporadically introduced into surgical practice over more than a century. This equipment is made by a wide variety of companies who have no incentive to coordinate with one another to create the most efficient operating room. Equipment throughout the operating room has been placed in one location or another, generally without a plan and then decades later, is still sitting in that unplanned location. For example, the first of the electronic monitors used during anesthesia was the electrocardiogram (ECG or EKG), which was introduced into the operating room in the 1960's. When EKGs became small enough to be placed on a shelf, getting it off of the floor, the most available shelf space somewhat near the patient, was above the anesthesia gas machine. As more anesthesia related electronic monitors were developed and introduced into practice over the next 40 years, they were simply stacked on top of one another on the same shelf above the anesthesia machine. Soon it was simply tradition that dictated that vital sign patient monitors are located over the anesthesia machine. Eventually the independent anesthesia related monitors were consolidated into single units for convenience. These consolidated multifunction anesthesia monitors were still placed on the same shelf above the anesthesia machine or on a mounting bracket attached to the anesthesia machine.

Just because a shelf happens to be available does not mean that the anesthesia related monitors are ideally located. The anesthesia machine is generally located to the side of and slightly behind the anesthetist, when standing at the head end of the surgical table facing the patient. In many cases, the anesthesia machine is located behind the anesthetist. Therefore, it is axiomatic that looking at or adjusting the anesthesia related monitors means that the anesthetist is not looking at the patient but rather looking away from the patient. Therefore, when the patient is experiencing a problem and the anesthesia related monitors are reporting confusing or adverse information, the anesthetist is focused away from the patient.

When the anesthesia related monitors are located in their present location over the anesthetic gas machine, the numerous wires, cables and hoses connecting the monitors to the patient are generally 10-12 feet long. There is a minimum of 5 wires and 2 hoses and frequently as many as 10 wires, cables and 2 hoses connecting the monitors to the patient. Electric patient warming blankets, mattresses and fluid warmers are also rapidly gaining acceptance. The controller for the electric warming products is generally located adjacent the anesthesia machine and the 3-6 cables connecting the controller to the warming blankets and mattresses on the patient are 12-15 feet long. Cables and hoses tangled and laying on the floor are clearly a problem in the operating room, causing not only inconvenience but getting contaminated and causing a tripping hazard for operating room personnel.

Cable and hose management on the surgical side of the anesthetic screen (e.g., sheet perpendicular to the table across the neck region of a patient) is also a problem that has developed haphazardly over the past century. Numerous pieces of surgical equipment have been parked somewhat randomly in the middle of the operating room, each causing an obstruction to traffic flow. Each of these pieces of equipment has a power cord or hose that lays on the floor extending to the wall outlet. Each of these pieces of equipment has one or more cables and/or hoses that lays on the floor extending to the sterile field of the surgical table. Every cable and hose on the floor is a hazard for tripping operating room personnel. Every cable and hose on the floor is an obstruction for other rolling equipment and carts and is at risk of damage from these carts, needing replacement.

A typical operating room (OR) has numerous alarms that monitor the patient's vital signs during a procedure, like heart rate and blood pressure, but the complication of multiple alarms ringing simultaneously, and frequent false positives creates a very distracting OR environment.

The various equipment such as electrosurgical units, smoke evacuation pumps, sequential compression sleeve pumps, blood/fluid suction units, and air mattress pumps are scattered about the operating room creating their own obstacles. Wherever the surgical equipment is located in the operating room on the surgical side of the anesthesia screen, the cables and hoses traverse to the sterile field on the surgical table by way of laying on the floor and becoming obstacles.

Waste heat and air discharged from heater-cooler units (HCU) near the floor can form into convection currents of rising warm air and mobilize bacteria up and into the sterile surgical field.

Flow-boundary layers of still air form next to the surgeons and anesthesia screen, preventing the downward airflow from even the best operating room ceiling ventilation systems from reaching the sterile field. When the ventilation airflow slows, the airborne contaminants and bacteria have the opportunity to settle into the open wound.

In some situations, oxygen and alcohol vapors trapped under the surgical drape pose a burn hazard to the patient in the presence of an electro-cautery spark.

Over the past 20 years, there has been a gradual movement to replacing paper anesthetic records with electronic anesthetic records (EAR). The electronic data outputs of the patient monitors have been relatively easy to input into the EAR. However, the identity, dosing and timing of IV and inhaled drug administration, IV fluid administration and oxygen and ventilation gas administration, has required manual input to the EAR by way of a computer keyboard and mouse. Blood, fluid and urine outputs as well as anesthetic events have also required manual input to the EAR by way of a computer keyboard and mouse.

SUMMARY

The modules, systems and methods described herein overcome various problems in the operating room. For example, like the cockpit of the fighter plane, the electronic monitors used during anesthesia and surgery should be located near the patient so that the anesthetist's field of vision simultaneously includes: the patient, the monitors and the surgical procedure. However, this is not the case in conventional operating rooms. The modules, systems and method described herein, overcome this and other problems in the operating room, creating a safer environment for the patient and the operating room personnel.

It would also be advantageous if the surgical support equipment and their cables, cords and hoses could be removed from the floor of the operating room.

A reduction of noises and interruptions associated with alarms meant to signal anesthesiologists, that frequently result in distractions to other OR personnel, would be beneficial.

A way of eliminating flow-boundary dead zones from obstructing the ventilation airflow and thus keeping the airborne contaminants and bacteria airborne and out of the wound, would be useful to protect the open wound from airborne contamination.

Waste heat and air discharged from heater-cooler units (HCU) near the floor can form into convection currents of rising warm air and mobilize bacteria up and into the sterile surgical field. Similar contamination of the sterile field with bacteria and contaminates from the floor has been shown in many studies of the waste heat and air from forced-air warming devices. The US Centers for Disease Control has warned that due to the positive link to implant infections, "Nothing that blows air should be in an operating theater, if possible." and " . . . it is important not to blow air in the operating theater." Therefore, there is a need to safely manage waste heat and air from surgical equipment and monitors in order prevent contamination of the sterile surgical field.

With regard to flammable alcohol and oxygen vapors concentrating in particular areas of the OR, eliminating the alcohol vapors and oxygen trapped under the surgical drape would add to the fire safety of the surgical experience.

Illustrative examples of a relocation module systematizes surgical safety for patients and OR personnel. In some examples, this module designed to house nearly all of the operating room patient monitors and support equipment. Even dissimilar types of equipment that are normally kept separate from one another. In some examples, this unique module is specially designed to fit next to and under the arm-board of the surgical table—a location traditionally occupied by an IV pole. For the past 100 years, this location has been a wasted "no-man's land" between the anesthesia and surgical sides of the operating room. In reality, the unique space next to and under the arm-board, is truly the "prime real estate" of the entire operating room: it is immediately adjacent the patient for optimal monitoring while simultaneously maintaining observation of the patient and surgical procedure; equipment controls can be conveniently accessed by both the anesthesia and surgical staff; short cables and hoses are adequate to reach the patient; and it is uniquely accessible from both the anesthesia and surgical sides of the anesthesia screen. The unique space next to and under the arm-board is the only location in the entire operating room where cables, cords and hoses from both the anesthesia side and the sterile surgical field side, do not need to traverse the floor or even touch the floor in order to connect to their respective monitor or patient support equipment—truly a remarkable location that has been wasted by conventional systems.

In some examples, an illustrative relocation module can house both anesthesia related and non-anesthesia related equipment. In some examples, the illustrative relocation module can house a variety of non-proprietary OR equipment such as patient vital sign monitors and electro-surgical generators. In some examples, the module is designed to also house newer proprietary safety equipment such as: air-free electric patient warming, surgical smoke evacuation, waste alcohol and oxygen evacuation, evacuation of the flow-boundary dead-zones that cause disruption of the OR ventilation and the evacuation and processing of waste heat and air discharged from OR equipment. In some examples, this module may also house dissimilar equipment (e.g., unrelated to anesthesia monitoring) such as: air mattress controls and air pumps; sequential compression legging controls and air pumps; capacitive coupling electrosurgical grounding; RFID counting and detection of surgical sponges; the waste blood and fluid disposal systems; and "hover" mattress inflators. Any of these devices may be stored in the relocation module together with (or without) anesthesia equipment.

In some examples, the relocation module is a specialized and optimally shaped rack for holding and protecting the patient monitors and other electronic and electromechanical surgical equipment, in a unique location. A location that is very different from just setting anesthesia monitors on top of the anesthesia machine and scattering other equipment across the floor of the operating room.

In some examples the preferred new location is adjacent the anesthesia side of one or the other of the out-stretched arm-boards of the surgical table, a location currently occupied by an IV pole on a rolling stand. In this location, the relocated monitor screens are 1-2 feet lateral to the patient's head, allowing the anesthesia related monitors, the patient and the surgical field to be observed by the anesthetist in a single field of vision. In some examples, with the monitors, the patient and the surgical field to be observed by the anesthetist in a single field of vision, it is highly likely that the anesthetist will be looking in that direction most of the time. Because the anesthetist is naturally looking toward the patient and monitors, a relatively bright warning light mounted on the tower or on one of the monitors that are mounted on the tower in this field of vision and aimed at the anesthetist, may be substituted for an audible alarm. The unique location of the tower on the module allows this warning light to be aimed away from the surgical field and it is therefore not distracting or even visible to the surgeon. Only if the warning light is ignored by the anesthetist, would a backup audible alarm which is distracting to the surgeon and OR staff be necessary.

Locating the module adjacent the arm-board has several advantages. First, that space is currently occupied by an IV pole, so it is not currently being used for personnel traffic. Second, the arm-board and the anesthesia screen above the arm-board, traditionally are the separation boundary between the anesthesia side of the operating room and the surgical side of the operating room—essentially an empty "no-man's land" between the two sides. The raised head end of the surgical drape that is tethered between two IV poles, creates a physical barrier between the anesthetist and the surgical field, is commonly known as the "anesthesia screen" or "ether screen." As a "no-man's land," the space under the arm-board is currently unoccupied. The space under the arm-board is unique in that it can be accessed from both the surgical and the anesthesia sides of the anesthesia screen. Access to the module from the surgical side can be from below the lower edge of the surgical drape hanging down over the arm board, or more conveniently from the side of the module facing away from the patient, at the distal end of the arm-board. There is no other location in the operating room that can be simultaneously accessed from both the surgical and anesthesia staff, while maintaining the traditional boundary or "no-man's land" between the two. Therefore, this location is uniquely suited for a module that can contain both surgical and anesthesia equipment.

In some examples, locating the module adjacent the arm-board means that one of the side faces of the module is facing the patient and is within 24 inches of the patients' head and chest. This location close to the patient allows for a cable and hose management system with relatively short cables and hoses, which are much easier to manage than long cables and hoses. The traditional long cables and hoses that need to reach from the patient to the electronic monitors located on top of the anesthesia machine by way of draping to the floor, are easily tangled, end up laying on the floor getting contaminated and damaged. The probability of cables becoming tangled are not linearly correlated to cable length but rather exponentially correlated with cable length. In other words, longer cables are far more likely to get tangled. Because they are a nuisance to wind for storage, they are frequently left lying on the floor or draped over a gas machine. Long cables and hoses are also difficult to clean.

In some examples, the side of the module facing the patient includes a cable management system. In some examples the cable management system comprises an array of straps with snaps or Velcro fasteners to retain the individual cables and hoses. In some examples the cable management system comprises an array of hooks to retain the cables and hoses. Other cable and hose retention mechanisms are anticipated.

In some examples, the cable management system includes cables that are naturally coiled during the process of forming (e.g., molding) the outer insulation, somewhat like the traditional telephone cord. In some examples, the coils of cable or hoses may be much larger diameter than the traditional telephone cord. Coils that are 2-5 inches in diameter, much like a "slinky" may be preferable. Coils of larger diameter may have superior "memory" to retain the coiled shape. Electrical insulation materials such as urethane and nylon also provide superior "memory" characteristics compared to the PVC coating historically used on telephone cords.

These larger coils are easily stretched because the elongation is accomplished primarily by the lateral movement of adjacent coils, basically elongating the tubular shape, a movement that is minimally opposed by the "memory" of the molding process. This contrasts with an attempt to unwind each of the individual coils, a movement that is maximally opposed by the "memory" of the molding process. This is identical to the principals the make a "slinky" work; very easy to stretch in the direction of the coiled tube but nearly impossible to unwind an individual coil. The larger coils easily stretch laterally between the planes of each adjacent coil and stretch minimally in the plane of each coil.

In some examples, the coils of the cable management system are created by extrusion molding an electrically insulating plastic sheath over the wires of the cable. In some examples, the coils of the cable management system are created by extrusion molding a coil of plastic tubing and then inserting the wires of the cable into the tubing as a second operation.

Each piece of equipment on the surgical side of the anesthesia screen has traditionally been mounted on castor wheels and parked freestanding, somewhere on the floor surrounding the surgical table. In these locations, each of these pieces of equipment require a power cord or vacuum hose that lays on the floor and extends from the individual equipment to the wall plug or outlet. Additionally, each piece of equipment also has one or more cables and/or hoses that extend from the sterile surgical field, down to the floor, across the floor and are then plugged into the equipment. The freestanding equipment in the middle of the operating room floor is an obstruction to the movement of personnel, carts and gurneys. The cords, cables and hoses laying on the floor create a tripping hazard for operating room personnel, and also create an obstruction to rolling carts.

In some examples, the module can solve these problems, and other problems as well. In some examples, the module includes a lower section that can fit under the arm-board of the surgical table, utilizing the currently wasted space under the arm-board. In some examples, this lower section may have a larger footprint than the tower-like upper section that may be located against the anesthesia side of the arm-board. In some examples, a bulbous-shaped lower section creates much more space and volume for accommodating more pieces of electronic and electromechanical equipment—the added volume filling the unused volume under the arm-board.

In some examples, the bulbous lower section allows heavier equipment to be mounted down low in the module for added stability. In some examples, the larger footprint of the bulbous lower section allows a broader base for added stability. In some examples, it may be advantageous to mount heavier equipment near the rear of the module to balance the weight of the tower-like upper section that may be mounted over the front of the bulbous lower section. This prevents the tendency for the forward mounted tower to cause forward tipping. In some examples, the module may be suspended from the ceiling of the operating room on a "boom." Equipment suspended from ceiling mounted booms are well-known in the operating room.

In some examples, the rear side of the bulbous lower section may be positioned approximately in the same plane as the surgical drape hanging down from the surgical side of the arm-board. The surgical drape generally terminates 18-24 inches above the floor, allowing the rear of the bulbous lower section to be uniquely accessed from the surgical side of the anesthesia screen, below the lower edge of the surgical drape. In some examples, electrical plug-ins and hose connections for the various pieces of surgical equipment housed in the module may be located on the rear side of the bulbous lower section.

Alternately or in addition, in some examples, if the staff prefers to access cable and hose plug-ins at a higher, more convenient level, the cable and hose plug-ins may be positioned on the side of the module facing away from the patient or on the top surface of the lower section, near the side of the module facing away from the patient, since there is no surgical drape hanging down in this area.

In some examples, cables and hoses exiting the sterile surgical field may uniquely be dropped off of the sterile field adjacent the anesthesia screen. From this location, the cables and hoses drop nearly straight down to be attached to the cable and hose plug-ins on the rear the bulbous lower section or the side of the bulbous lower section facing away from the patient. In this unique location, there is no need for the cables and hoses to lay on the floor while traversing the distance to the equipment. In this unique location, there is no need for the cables and hoses to even touch the floor while traversing the distance to the equipment. This unique location next to the surgical drape and below the arm-board is the only place in the entire operating room where cables and hoses from supporting equipment can access the sterile surgical field without traversing or even touching the floor of the operating room and creating a tripping hazard for operating room personnel.

In some examples, consolidating the surgical equipment into the module also eliminates the obstructions caused by that equipment when it is free-standing in the middle of the operating room floor. It also eliminates the need for power cords and vacuum hoses traversing the floor to connect the equipment to the wall outlets.

Locating electrical and electromechanical equipment under the arm-board, can subject that equipment to a potential hazard from spilled water, spilled saltwater (saline) and blood. In some examples, in order to protect this equipment from spilled fluids, the module is substantially covered in a water-resistant housing or "cowling."

For many decades, it has been an accepted axiom in the operating room; the air below the level of the surgical table is contaminated with skin cells (squames) and bacteria shed from the skin of the surgical personnel. These squames are shed from the skin of the operating room personnel into the air of the operating room. Once airborne, the squames are pushed toward the floor and vents near the floor, by the downward operating room ventilation airflow.

Waste heat from surgical equipment released near the floor, for example, heater-cooler units and forced-air warming units, has been proven to form into convection currents of rising warm air. When this waste heat is released near the floor, the rising convection currents can mobilize contaminates and bacteria that normally resident near or on the floor, up and into the sterile surgical field. If waste heat could be prevented from being within 4 feet of the floor where most of the airborne contaminates are concentrated, basically the height of the surgical table, it is believed that infections can be reduced.

The various pieces of electronic and electromechanical equipment housed within the module disclosed herein can produce relatively large amounts of waste heat. The bulbous lower section of the module is placed on the floor next to the surgical table and is below table height since it is under the arm-board. Releasing waste heat in this location on the floor next to the surgical table may cause a risk of sterile field contamination from the rising waste heat that may include squames and other contaminants. In some examples, the module may include a waste heat management system to safely dispose of the waste heat created by the electronic and electromechanical equipment housed within the module.

It would be difficult or even impossible to manage the uncontained waste heat produced by electronic and electromechanical equipment mounted on a simple open rack because it can escape in any direction. In some examples, the module can include a "cowling" covering substantially the entire outer surface. The cowling not only protects the equipment from accidental fluid damage but also confines the waste heat from the electronic and electromechanical equipment mounted within the module, to the inside of the module and cowling. In some examples, the confined waste heat can then be safely managed.

In some examples, the cowling cover of the module can form or support a waste heat management system. In some examples, the cowling can be provided on an inner surface of the housing, In some examples, the cowling can be described as an insulation. In some examples, the housing can include other types of insulation from heat and/or water. Any suitable type of insulated housing suitable for use in a surgical field can be provided.

In some examples, the module includes a tower-like upper section attached to the topside of the lower section. In some examples, the tower-like upper section extends substantially vertically from the top side, near the front of the lower section. In some examples, the tower-like upper section is used for mounting monitor screens and cable management retentions at an easily accessible and convenient height. In some examples, the top of the tower-like upper section, is 5 feet or more above the operating room floor. At this height, waste heat can be exhausted from vents near the top of the tower-like upper section is vented into the operating room, well above the height of most airborne contaminates. In contrast, if the waste heat vented low (<4 feet above the floor), it may mobilize airborne contaminants up and into the sterile field causing a significant infection risk.

In some examples, the cowling of the tower-like upper section serves as a chimney, containing the rising waste heat until it can be safely discharged from outlet vents located near the top of the tower. In this case, air may be allowed to enter the module through inlet vents in the lower section, the air gets heated by the electronic and electromechanical equipment in the module and then by natural convection, the heated air rises within the tower-like upper section and is discharged through outlet vents near the top. In some examples, a filter and fan may be added to the waste heat management system in order to filter the waste heated air before discharging it into the operating room, or to filter inlet air.

In some examples, the inlet vents for the cooling air may be located in the tower-like upper section, above the level of the airborne contamination. At this level, the inlet air is relatively pure and therefore there is no risk of contaminating the equipment housed within the module with contaminated air. In some examples, a duct may connect the inlet vent in the tower-like upper section to the equipment space in the lower section. The clean inlet air may be drawn into inlet vents mounted high on the upper section and then ducted down to the equipment that needs cooling and then ducted back up to the tower to be discharged at a safe height above the airborne contaminates. In some examples, ionized air filter plates may be included in the ducting to provide added filtration of the air without added resistance to the airflow.

In some examples, a waste air management system may be included in the module. In this case, the waste air management system may be designed to safely process and discharge waste air that may or may not contain waste heat. The waste air may be the by-product of equipment contained within the module or may be a waste product of other OR equipment, besides the monitors. An example of waste air producing equipment may include the smoke evacuation suction; used for evacuating electrosurgical smoke and filtering the smoke which has been shown to periodically contain virus particles.

Waste air producing equipment can also include operating room ventilation dead zone evacuation equipment; by vacuuming the air from the flow-boundary dead zones that naturally forms in front of the surgeons and anesthesia screen, the interference of the flow-boundary layers with the operating room ventilation can be reduced. This allows the ventilation airflow from the ceiling to reach the wound unimpeded by a flow-boundary dead zone. When ventilation airflow is kept moving, airborne contaminates in that air are kept airborne. As long as the airborne contaminates remain airborne, they do not land in the wound where they can cause an infection. When the ventilation airflow slows or even stops due to dead zone interference, gravity takes over and the airborne contaminates settle into the wound where they may cause infections. These dead zones of non-moving air that interfere with the operating room ventilation can be evacuated by placing vacuum hoses into the dead zone. The evacuated air can then be processed in order to safely discharge the air, back into the operating room. In some examples, the ventilation dead zone evacuation system may simultaneously serve as the surgical smoke evacuation suction. In this case the vacuum hose does not need to be attached to the electrosurgical pencil electrode, which many surgeons find to be cumbersome.

Waste air producing equipment can also include heater-cooler units (HCU) that produce contaminated waste heated air that needs to be processed and safely discharged. In this case, the waste heated air is a byproduct of cooling the refrigeration compressor of the HCU. Forced-air warming units (FAW) also produce contaminated waste heated air that needs to be processed and safely discharged. The FAW systems exhaust waste air from under the surgical drape where it escapes from under the surgical table near the floor. In some examples, this waste heated air can be contained and vacuumed up for safe disposal. Electrosurgical units and other surgical equipment also produce waste heated air that needs to be processed and safely discharged.

In some examples, the waste air management system may be used to evacuate and/or dilute the air under the surgical drape, especially near the patient's head, neck and chest. Alcohol from the surgical prep solution may pool under the drapes and then evaporate providing fuel for a fire. Waste oxygen from an unrestricted oxygen supplementation system such as nasal prongs may also pool under the drapes providing an oxidant for a fire. Then, add a spark from either the electro-cautery or a laser and highly dangerous operating room fires can occur. These fires occur far too frequently. Even the surgical drape can burn in the presence of an oxygen-enriched environment.

In some examples, it may be advantageous to remove the air and oxygen and alcohol vapors trapped under the surgical drape. In some examples, a vacuum hose may be placed near the shoulders, chest and neck of the patient. In some examples, the proximal end of the vacuum hose may plug into the inlet side of the waste air management system, for a convenient source of low velocity, low pressure vacuum.

In all of the instances, the waste heated air can be vacuumed, filtered and discharged at a height that does not allow any waste heat to mobilize contaminates normally resident near the floor, up and into the sterile field. In a possibly preferred example, the air discharge can be at a height that is greater than 4 feet off of the floor.

In some examples, the waste air management system includes an air plenum containing an air filter. One or more air inlets allow waste air to enter the plenum from either the equipment housed in the module or from external equipment sources. A fan propels the waste air through the filter and exhausts the air from the plenum into a substantially vertical vent tube. In some examples, the substantially vertical vent tube extends upward to a height of more than 5 feet above the floor, before discharging the processed waste air from outlet vents near the top of the substantially vertical vent tube. In some examples, ultraviolet lights (UV) may be included in the plenum on one or both sides of the filter. In this location, the UV radiation can kill any living organisms that may have been captured by the filter. In some examples, a fabric sock-like filter may be attached to an outlet vent. The sock-like filter diffuses the air being discharged into the operating room to avoid jets and turbulent air currents. A sock-like filter can muffle the sound of the fan reducing OR noise created by various equipment cooling and smoke evacuation fans.

In some examples, the substantially vertical vent tube may be a rigid tube. In some examples the substantially vertical vent tube may traverse mostly in a vertical direction but can include non-vertical portions. In some examples, the substantially vertical vent tube may be the tower-like upper section of the module. In some examples, the substantially vertical vent tube is an inflatable, collapsible tube made of fabric, plastic film or fabric laminated to or coated with a plastic film. In some examples, the inflatable, collapsible tube may be disposable.

In some examples, the inflatable tube includes a substantially sealed distal end with one or more holes in the walls of the tube to allow the air to escape but create a flow obstruction causing the pressure within the inflatable tube to increase. The increased pressure in the inflatable tube causes the inflatable tube to assume an erect shape. In some examples, the erect inflatable tube extends substantially vertically, in order to terminate at a height of more than 5 feet above the floor. In some examples, the erect inflatable tube extends diagonally at an upward angle.

In some examples, it may be advantageous to dilute the air and oxygen and alcohol vapors trapped under the surgical drape with air. In some examples, an air hose may be placed near the shoulders, chest and neck of the patient. In some examples, a proximal end of the air hose may plug into a diversion from the discharge side of the waste air management system, for a convenient source of low velocity, positive pressure air.

In some examples, the output of the waste air management system may be diverted into a hose that may be hooked to an inflatable "hover" mattress for moving the patient off of the surgical table at the end of surgery. These "hover" mattresses are known in the arts and are inflated with pressurized air, which is released through holes on the bottom side of the mattress. The released air is effectively trapped under the mattress forming an air cushion on which the mattress and the patient effectively float, allowing the patient to be easily slid from the table to the gurney.

In some examples, the fan in the waste air management system also conveniently provides the pressurized air for a "hover" mattress. Air may be diverted from the outlet side of the waste air management system, into a hose that is attached to a "hover" mattress.

In some examples, the module of the instant invention may also contain the components of the anesthesia gas machine. So-called "gas machines" are relatively simple assortments of piping, valves, flow meters, vaporizers and a ventilator. These could be located within the module or attached to the module for further consolidation of equipment and for improved access to the patient. The close proximity to the patient not only shortens the ventilation tubing but also shortens the sampling tubing for the carbon dioxide monitor. The close proximity of the anesthesia gas machine to the patient also allows continuous observation of the patient while adjusting the gas and anesthetic flows.

In some examples, the module (e.g., **10**) may include an air/oxygen blender to supply oxygen-enriched air to the patient for facemask and nasal prong delivery. This may be especially advantageous because of the very short distance between the module and the patient's head. Adding an air/oxygen blender may also be advantageous because many of the anesthesia machines do not include these devices. In some examples, the emergency oxygen, air and nitrous oxide tanks for the anesthesia machine may be mounted on the lower portion of the module in order to keep the center of gravity as low as possible. In some examples, it may be advantageous to mount these tanks horizontally on the sides or rear of the lower portion of the module rather than their traditional vertical mounting orientation, in order to avoid interfering with the arm board of the surgical table. In some examples, it may be advantageous to mount these tanks diagonally on the sides of the lower portion of the module rather than their traditional vertical mounting orientation, in order to avoid interfering with the arm board of the surgical table. In this case, a tank that is longer than the depth of the module can still be accommodated by locating the valve of the tank at the upper end of the diagonal near the front of the module. The closed end of the tank can thus be located at the lower end of the diagonal near the rear of the module where it fits nicely under the arm-board. In some examples, the oxygen, air and nitrous oxide hoses supplying the anesthesia machine may advantageously hang from the ceiling and connect to gas inlets in the top of the upper section of the module. In this location, the gas hoses are uniquely unobtrusive to the operating room staff.

In some examples, locating the anesthesia machine in or on the module allows direct access for and sensors and monitors related to the anesthesia machine, to input data to the electronic anesthetic record being recorded by equipment in the module.

In some examples, the shared fan, plenum, filter and discharge system of the waste air management system improves the efficiency, space requirements and cost in the operating room by consolidating multiple pieces of equipment into one. Currently, individual pieces of surgical equipment that produce waste air and waste heat are generally located on the floor, somewhere around the surgical table. This is exactly the worst place for this equipment to be located because the waste air and heat from this equipment is vented near the floor. The waste heat and air can then heat the contaminated air normally resident near the floor, and then carry contaminating particles and bacteria from the floor, up and into the sterile surgical field. Consolidating all the surgical support equipment in the bulbous lower section of the module with a single waste air management system eliminates waste air and heat from being vented near the floor, reducing the risk of airborne contamination.

Locating that single waste air management system in the bulbous lower section of the module and placing it under the arm-board of the surgical table totally removes it from all operating room traffic while providing the shortest possible hose distance to the patient, either on the surgical or anesthesia side of the anesthesia screen. Locating the waste air management system under the arm-board and surgical drape also minimizes and muffles the annoying fan noise.

Poor teamwork between anesthesia and surgery may be due to poor communication. For example, the anesthesia personnel may be experiencing problems maintaining normal vital signs and this may not be communicated quickly and clearly to the surgeon. "Yeah, the anesthesiologist mentioned his blood pressure was decreasing but I didn't realize it was to a critical level, so I went ahead and finished the procedure." A failure of the surgeon to understand the situation, can result in a wide variety of complications ranging in severity from mild to fatal. In some examples, a solution to this problem may be to mount a vital signs display screen on the rear of the tower-like upper section of the module, facing the surgeon. In this unique location viewable over the top of the anesthesia screen, the surgeon can be constantly aware of the patient's vital signs.

In some examples, the collection canisters for waste fluid and blood may be conveniently mounted on the module. Mounting the canisters on the module eliminates the need for vacuum tubing to lay on the floor while traversing from the wall outlet to the canister and from the surgical field to the canister. Optical or infrared fluid level sensors **153** may be conveniently mounted in the module, adjacent the canister(s). In some examples, the fluid level monitors may automatically activate or deactivate the vacuum to a given canister, thereby automatically shifting the blood and fluid flow to a new canister as the previous one is filled.

In some examples, the controls and display screens for the surgical equipment housed in the module may be wirelessly connected to a portable display screen such as an iPad or "smart tablet," for convenient access by the nurse anywhere in the room. This allows the surgical nurse to monitor and control the equipment without walking across the room. This is convenient for the nurse and increases awareness of equipment conditions. Staff moving around the OR kick up contaminates from the floor into the air where they can be carried to the sterile surgical field by waste heat. A portable display screen minimizes surgical staff movement in the OR which has been shown to reduce airborne contamination and surgical site infections.

Doctors and nurses dislike record keeping and the switch to the electronic record has made the act of record keeping more difficult and time consuming. Entering the electronic record into the computer sometime after the event occurred and the case has settled down, is not only distracting from patient care but leads to inaccurate records. Hand entered records also bypass the opportunity for the computer to add to patient safety by checking drug identities, dosages, side effects, allergies and alerting the clinician to potential problems or even physically stopping the drug administration. Manually entered records are not useful for managing drug inventories because a given medication administration is not tied to a specific drug bottle or syringe. Finally, the computer mouse and keyboards have been shown to be contaminated by a wide variety of infective organisms and are virtually impossible to clean. Automatic anesthetic data entry to the EAR would improve patient safety, improve clinician job satisfaction and improve OR inventory management.

In general, doctors and nurses are not interested in replacing themselves and their jobs with automated drug delivery or automated anesthesia systems. However, they may be more open to automated record keeping. The challenge with automated record keeping is automating the data input that documents the numerous activities, anesthesia related events, fluid, gas and medication administration that constitute an anesthetic experience or another medical situation

The second challenge in implementing an automated electronic anesthetic record (EAR) or electronic medical record (EMR) is to force as little change in routine as possible onto the anesthesiologist and other clinicians using this system. Anesthesiologists and surgeons are notoriously tradition-bound and resistant to any changes in their "tried and true" way of doing things. Therefore, a successful automated EAR must interact seamlessly with current anesthesia practices and operating room workflow without causing any disruptions.

In some examples, the automated EAR of this disclosure includes a system for automatically measuring and recording the administration of IV medications and fluids. The system for automatically measuring and recording the administration of IV medications and fluids can include one or more sensors, such as one or more of a barcode reader and an RFID interrogator for accurately identifying a medication or fluid for IV administration.

The system for automatically measuring and recording the administration of IV medications and fluids can also include one or more digital cameras with machine vision software ("machine vision") for accurately measuring the volume of medication administered from a syringe or fluid administered from an IV bag through a drip chamber into an IV tubing. The digital cameras with machine vision software essentially duplicate the clinician's vision of an activity, injection of a drug from a syringe for example, without interfering in the normal activity and yet allows automatic recording of the activity in the EAR. The machine vision software can include one or more machine-readable mediums that when implemented on hardware processing circuitry of the system or in electrical communication with the system, can perform the functions described herein.

In some examples, the automated EAR of this disclosure uses machine vision to unobtrusively "observe" the flow rate of the ventilation gas flow meters and inhaled anesthetic vaporizers.

In some examples, the automated EAR of this disclosure captures input data from the blood and fluid collection and urine output collection systems of this disclosure.

In some examples, the automated EAR of this disclosure captures anesthetic event data by capitalizing on the fact that anesthesiologists, surgeons and nurses compulsively tend to meticulously follow their routines. For example, a particular anesthesiologist may routinely intubate all adult male patients with an 8.0 endotracheal tube unless there is an abnormality. Therefore, if the EAR knows who is providing the anesthesia, knows their preferences and knows that the patient is an adult male, the automated EAR can "automatically" enter the intubation event into the record and will be correct more than 95% of the time. In the unusual event of a patient abnormality requiring an alteration of the routine, the anesthesia provider can manually enter the variant information to provide an accurate record. In some examples, the relative rarity of data being manually entered into the EAR allows for the elimination of the computer keyboard and mouse, to be replaced by an easy-to-clean touch screen display.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, which are not necessarily drawn to scale, like numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components. The drawings illustrate generally, by way of example, but not by way of limitation, various examples discussed in the present document. Any combination of the features shown and described in this disclosure, including combinations of fewer or more features is within the content of this disclosure. Modules, systems and methods including individual features described herein, without combinations of features as shown in the examples (for the sake of brevity), are also within the scope of this disclosure

FIG. **1** shows a perspective view of an illustrative module that can include storage, airflow and cord management systems, among other systems, in accordance with at least one example.

FIG. **2** shows a perspective view of an example standard operating room including a surgical table, and a patient laying on the table, in accordance with at least one example.

FIG. **3** shows a perspective view of the example standard operating room of FIG. **2**, including two IV poles and a surgical drape, in accordance with at least one example.

FIG. **4** shows a perspective view of the illustrative module of FIG. **1** in an operating room, in accordance with at least one example.

FIG. **5** shows a perspective view of another example of an illustrative module, in accordance with at least one example.

FIG. **6** shows a perspective view of another example of an illustrative module, in accordance with at least one example.

FIG. **7** shows a perspective view of another example of an illustrative module, in accordance with at least one example.

FIG. **8** shows a side view of an illustrative example of a cable and hose management system of the illustrative system of FIG. **4**, in accordance with at least one example.

FIG. **9** shows a side view of another illustrative example of a cable and hose management system of the illustrative system of FIG. **4**, in accordance with at least one example.

FIG. **10** shows a side view of another illustrative example of a cable and hose management system of the illustrative system of FIG. **4**, in accordance with at least one example.

FIG. **11** shows a side view of another illustrative example of a cable and hose management system of the illustrative system of FIG. **4**, in accordance with at least one example.

FIG. **12** shows a side view of an illustrative individual cable and hose management system of FIG. **11**, in accordance with at least one example.

FIG. **13** shows a rear view of an illustrative cord of the cable and hose management system of FIG. **11**, in accordance with at least one example.

FIG. **14** shows a perspective view of the illustrative system of FIG. **10** with two of the cables unwound and attached to the patient, in accordance with at least one example.

FIG. **15** shows a rear view of a storage bracket and cable of the illustrative system of FIG. **11**, in accordance with at least one example.

FIG. **16** shows a side view depicting internal components of an illustrative waste air management system that can be used with the system of FIG. **11**, in accordance with at least one example.

FIG. **17** shows a side view depicting internal components of another illustrative waste air management system that can be used with the system of FIG. **11**, in accordance with at least one example.

FIG. **18** shows a side perspective view of an illustrative module including an example vent tube, in accordance with at least one example.

FIG. **19** shows a side perspective view of another module including another illustrative vent tube, in accordance with at least one example.

FIG. **20** shows an illustrative waste air management system including an illustrative vacuum hose, in accordance with at least one example.

FIG. **21**A shows an illustrative surgical field depicting flow-boundary dead zones, in accordance with at least one example.

FIG. **21**B shows the surgical field of FIG. **21**A including an illustrative ventilation optimization system for improving the flow-boundary dead zones of FIG. **21**A, in accordance with at least one example.

FIG. **21**C is a top view of the surgical field and the ventilation optimization system of FIG. **21**B, in accordance with at least one example.

FIG. **22** shows an example of an air dilution system that can be used with the systems described herein, in accordance with at least one example.

FIG. **23** shows a surgical field viewed facing towards an anesthesia screen from a surgical side of the screen with a surgeon positioned in a surgery performing position, and an illustrative system (e.g., any of the systems described herein) positioned adjacent a surgical table, in accordance with at least one example.

FIG. **24** shows a surgical field viewed facing towards an anesthesia screen from a surgical side of the screen with a surgeon positioned in a surgery performing position, and an illustrative system positioned adjacent a surgical table, in accordance with at least one example.

FIG. **25** shows a surgical field viewed facing towards an anesthesia screen from a surgical side of the screen and with a surgeon positioned in a surgery performing position, and an illustrative module positioned adjacent a surgical table, in accordance with at least one example.

FIG. **26** shows a perspective view from the anesthesia side of a surgical field of a patient on a surgical table, and an illustrative system at least partially disposed under an armboard of the table, in accordance with at least one example.

FIG. **27** shows a side view of an illustrative distribution pod hanging from a side rail of a surgical table, in accordance with at least one example.

FIG. **28** shows a perspective view of an illustrative system including fluid suction canisters, in accordance with at least one example.

FIG. **29** shows a side view of an illustrative fluid suction bag that may be used with the systems described herein, in accordance with at least one example.

FIG. **30** shows perspective view of an illustrative sanitizing system including UV lights, in accordance with at least one example.

FIG. **31** shows a perspective view of the illustrative sanitizing system of FIG. **30** depicting features of the UV lights, in accordance with at least one example.

FIG. **32**A shows a side view of an illustrative distribution pod not attached to a side rail, in accordance with at least one example.

FIG. **32**B shows a side view of a distribution pod angled and being placed on to a side rail, in accordance with at least one example.

FIG. **32**C shows a side view of a distribution pod attached to and hanging from a side rail, in accordance with at least one example.

FIG. **33** illustrates a system, in accordance with at least one example.

FIG. **34** illustrates a flow chart showing a technique for operating a module, in accordance with at least one example.

FIG. **35** illustrates another flow chart showing a technique for operating a module, in accordance with at least one example.

FIG. **36** illustrates another flow chart showing a technique for operating a module, in accordance with at least one example.

FIG. **37** illustrates another flow chart showing a technique for operating a module, in accordance with at least one example.

FIG. **38** illustrates another flow chart showing a technique for operating a module, in accordance with at least one example.

FIG. **39** illustrates another flow chart showing a technique for operating a module, in accordance with at least one example.

FIG. **40** illustrates another flow chart showing a technique for operating a module, in accordance with at least one example.

FIG. **41** illustrates generally an example of a block diagram of a machine (e.g., of module **10**) upon which any one or more of the techniques (e.g., methodologies) discussed herein may perform in accordance with some embodiments.

FIG. **42** illustrates an isometric view of an example system for generating an automated electronic anesthetic record located proximate to a patient, in accordance with at least one example.

FIG. **43** illustrates a plan view of an example of preloaded syringes **200**A and **200**B that can be used with the system of FIG. **42**, in accordance with at least one example.

FIG. **44** illustrates a side view of an example medication identification and measurement system and a syringe that can be used with the system of FIG. **42**, to monitor drug delivery, in accordance with at least one example.

FIG. **45** illustrates a cross-sectional view of the medication identification and measurement system and a syringe (not shown in cross-section) of FIG. **44**, taken along line **45-45**, in accordance with at least one example.

FIG. **46** illustrates a side view of a second example medication identification and measurement system and a syringe that can be used with the system of FIG. **42**, in accordance with at least one example.

FIG. **47** illustrates a cross-sectional view of the second example of a medication identification and measurement system and the syringe (not shown in cross-section) of FIG. **46**, taken along line **47-47**, in accordance with at least one example.

FIG. **48** illustrates a side view of a third example of a medication identification and measurement system and a syringe that can be used with the system of FIG. **42**, in accordance with at least one example.

FIG. **49** illustrates a cross-sectional view of the third example of a medication identification and measurement system and the syringe (not shown in cross-section) of FIG. **48**, taken along line **49-49**, in accordance with at least one example.

FIG. **50** illustrates an example injection port cassette that can be used with the system of FIG. **42**, as detailed in **45**, **47** and **49**, in accordance with at least one example.

FIG. **51** illustrates a side view of an example IV fluid identification and measurement system **230** that can be used with the systems of FIGS. **42-49**, and injection port cassette of FIG. **50**, in accordance with at least one example.

FIG. **52** illustrates side view of an example of a gas flow meter system that can be used with the system of FIG. **42**, in accordance with at least one example.

FIG. **53** illustrates a top view of the example gas flow meter system of FIG. **52**.

FIG. **54** illustrates a side view of an example anesthetic gas vaporizer monitoring system that can be used with the system of FIG. **42**, in accordance with at least one example.

DETAILED DESCRIPTION

The following detailed description is exemplary in nature and is not intended to limit the scope, applicability, or configuration of the invention in any way. Rather, the following description provides practical illustrations for implementing exemplary examples of the present invention. Examples of constructions, materials, dimensions, and manufacturing processes are provided for selected elements, and all other elements employ that which is known to those of skill in the field of the invention. Those skilled in the art will recognize that many of the examples provided have suitable alternatives that can be utilized.

As described herein, operably coupled can include, but is not limited to, any suitable coupling, such as a fluid (e.g., liquid, gas) coupling, an electrical coupling or a mechanical coupling that enables elements described herein to be coupled to each other and/or to operate together with one another (e.g., function together).

In some examples, a module includes an equipment rack in a protective housing or "cowling." The module can be designed to advantageously fit into the unique location adjacent and/or under the arm-board of the surgical table—a location currently occupied by an IV pole on a rolling stand.

An example of such a module is shown in FIG. **1**, the module **10** (and variations of module **10**) can include a system to provide any combination of features described herein. In some examples, the module **10** can include features such as storage of unrelated surgical equipment, control and/or filtering airflow and waste heat, a cord management system, sanitizing system, waste fluid system, air vacuum system, fluid dispensing system, display system, and a user input system and any other system described herein. These systems can also be provided individually and still provide benefits; the combinations are not required.

As shown in FIG. **2**, the standard operating room includes a surgical table **22** on which the patient **24** is laying. Typically, the surgical table **22** includes arm-boards **26** that are attached to side rails of the table **22** and extend laterally from the table **22** at a slightly less than perpendicular angle. The patient's arms are rested on the arm-boards **26**, which help to protect the arms from nerve damage and allow convenient access to the IV tubing. This general configuration for surgery has evolved over the past century and is now a firmly embedded tradition.

As shown in FIG. **3**, there are typically two IV poles **42** that are positioned adjacent the anesthesia side of the arm-boards **26**, one on each side of the surgical table **22**. Typically, the head end of the surgical drape **32** is elevated and attached between the two IV poles **42**, creating a barrier between the surgical field and the anesthesia personnel who are located at the head end of the surgical table **22**. This anesthesia screen **30** is a tradition that is meant to prevent skin contaminates shed from the anesthesia providers who are not wearing sterile gowns, from contaminating the sterile field.

The standard surgical draping shown in FIG. **3** naturally leads to surgery-related personnel and equipment being relegated to the surgical side **36** of the anesthesia screen **30**. Further, the anesthesia-related personnel and equipment are naturally relegated to the anesthesia side **34** of the anesthesia screen **30**.

Effectively, the anesthesia screen **30** and arm-boards **26** and the space under the arm-boards **26** have evolved into a "no-man's land" separating the surgical side **36** from the anesthesia side **34**. Except for the IV pole **42** holding up the anesthesia screen **30**, this "no-man's land" is totally wasted space in the modern operating room.

In some examples, as depicted throughout this disclosure, a module **10** (e.g., FIG. **4**) of this invention not only advantageously utilizes the currently wasted space under and adjacent the arm-board **26**, but also capitalizes on the uniqueness of that wasted "no-man's land" floor space and the volume under the arm-board **26**.

In some examples, the uniqueness of the space under and adjacent to the arm-board **26** includes but is not limited to the fact that it is less than 2 feet from the patient's head and less than 1 foot from the patient's arm. This is the only location in the operating room from which cables, wires, hoses and IV tubing do not need to traverse a walkway or lay on the floor, in order to reach the patient **24**.

As shown in FIGS. **2** and **3**, typically, an anesthesia gas machine **40** is located to the side of and slightly behind the anesthetist, who should be standing at the head end of the surgical table. Wires, cables and hoses originating from patient monitors **38** must necessarily traverse across the distance between the anesthesia gas machine **40** and the patient **24**. The wires, cables and hoses connecting the patient monitors **38** to the patient **24** are generally 10-12 feet long. The wires, cables and hoses hang to the floor, then traverse the floor and then ascend to the patient **24** laying on the surgical table **22**. It is axiomatic that 5-8 monitoring cables and hoses along with 2-6 electric patient warming cables (e.g., that are 12-15 feet long), can create a tangled mess laying on the floor.

The tangled mess of cables and hoses on the floor create not only considerable additional work for the OR staff requiring coiling and cleaning between cases, but also create a tripping hazard for the staff. Finally, cables and hoses laying on the floor of the OR are easily damaged by rolling carts and gurneys.

However, in the example systems described herein, the close proximity of the space adjacent the arm-board **26** is taken advantage of to provide for shorter monitoring, warming system and equipment cables and hoses. In some examples, this short distance to the patient eliminates the cables and hoses from even touching the floor, much less traversing the floor. In some examples, this is accomplished by relocating the patient monitors **38** into the module **10**. However, in some examples, the monitor electronics **38** may remain located at a distance from the surgical table **22**, perhaps on the anesthesia gas machine **40**, with only the terminations of the patient monitor **38** cables and hoses attached to module **10**. In some examples, the cables may be connected to the monitors located a distance away from the surgical table **22**, by wireless communications or by a trunk cable.

As shown in FIG. **4**, in some examples, the module **10** can occupy a unique space under and adjacent to the arm-board **26**. Benefits of this location include but are not limited to the fact that it is less than 2 feet from the patient's head and less than 1 foot from the patient's arm. Additionally, a benefit of the module **10** fitting into this unique location is that it is the only location in the operating room from which the patient monitoring displays **38**A, **38**B can be viewed by the anesthetist in the same field of vision as the patient's head and the surgical field, while standing at the head end of the surgical table **22**.

This location is in sharp contrast to the current location of patient monitor **38** mounted on the anesthesia gas machine **40** beside and behind the anesthetist. If the anesthetist is looking sideways at the patient monitors **38** located on the anesthesia machine **40**, he or she is clearly not simultaneously observing the patient (e.g., observing signs of distress or alertness on the face of the patient). Looking sideways at the monitors **38** located on the anesthesia machine **40**, as is traditionally done, is a whole different field of vision—away from the patient, a distraction from the primary monitor: observation of the patient.

Currently, when the patient monitors **38** audibly alarm, the anesthetist's attention is drawn away from the patient to the monitors **38**, accentuating the distraction caused by the current location of the patient monitors **38** on the anesthesia machine **40**. In some examples, the module **10** makes it possible for the anesthetist to observe not only patient monitor displays **38**A, **38**B, the patient **24** and the surgical field in a single field of vision, but also an alert or alarm light **11** shining from that field of vision back toward the anesthetist. In some examples, the light **11** may substitute for an audible alarm. Audible vital sign alarms from the patient monitors **38** are not only distractions for the surgical staff but significantly add to the noise in the OR. In some examples, one or more relatively bright warning lights **11** mounted on a tower **20** or on one of the patient monitors **38**A, **38**B that are mounted on the tower **20** in this field of vision and advantageously aimed at the anesthetist, may be substituted for audible alarms.

In some examples, the warning or alarm light **11** may advantageously be a directional LED that focuses its light in specific direction—toward the anesthesia provider. Mounting the one or more alarm lights **11** on the patient monitor display **38**A or **38**B that is adjustably mounted on the tower **20** to provide the best viewing angle to the anesthetist, will automatically preferentially aim the alarm light(s) **11** at the anesthetist. Lights mounted anywhere else may not aim at the anesthetist most of the time. Even lights mounted on a display of the patient monitor **38** would not usually be aimed at the anesthetist when the display of the patient monitor **38** is located in its traditional location on the anesthesia gas machine **40** located to the side of the anesthetist. In contrast, the location of the tower **20** (e.g., of module **10**) next to the patient with the patient monitor display **38**A, **38**B mounted on the tower at eye level and adjustably "aimed" at the anesthetist, uniquely allows lights **11** mounted on the patient monitor display **38**B or tower of the module **10** to be substituted for audible alarms. In some examples, if the alarm condition is severe, the light **11** may flash to increase noticeability. The warning or alarm lights **11** may advantageously be red but other colors including white are anticipated. In some examples, the lights **11** may be color coded, for example: patient monitor alarms may be red; IV infusion pump alarms may be orange; oxygen and ventilator alarms may be yellow; and miscellaneous non-critical equipment alarms such as warming blankets, may be blue.

In some examples, when the anesthetist acknowledges the alarm light **11** by pressing a button (or functionally equivalent response), the light **11** may decrease in intensity. In some examples, the light **11** automatically turns off only when the alarm condition is resolved. In some examples, if the anesthetist fails to acknowledge the alarm light **11** by pressing a button within a given amount of time, for example 20-30 seconds, a backup or secondary audible alarm may sound. In some examples, if the anesthetist acknowledges the alarm light **11** by pressing a button (or functionally equivalent response) within a given amount of time, for example 20-30 seconds, the backup audible alarm may be muted so as not to distract the surgical staff and add to OR noise. In some examples, if the overhead lights in the OR have been dimmed, the alarm light **11** may automatically decrease in intensity so as not to be an unnecessary distraction to the surgical staff.

The unique location of the tower **20** on the module **10** allows these one or more warning lights **11** to be aimed away from the surgical field, which is therefore not distracting to the surgeon. Only if the warning light **11** is not noticed or ignored by the anesthetist, would a backup audible alarm which is distracting to the surgeon and OR staff be necessary.

In some examples, the patient monitors and monitor display screens **38**A, **38**B may be located on the module **10** next to the patient. In some examples, the patient monitor display screens **38**A, **38**B may be located on the module **10** next to the patient, while the monitor electronics **38**C may remain mounted to the anesthetic gas machine **40** or elsewhere (e.g., FIG. **4**). In this instance, the output of the patient monitors **300**A, **300**B may be wirelessly transmitted to at least one patient monitor display screens **38**A, **38**B mounted on module **10**, for convenient viewing. In some examples, the patient monitor display **38**A, **38**B can include a small digital LCD projector or equivalent electronic projector may be mounted on the module **10** or on an articulating mount connected to module **10**, next to the patient. From this location, the projector may be used to project vital signs and other monitor information on to the anesthesia screen **30**, or another screen substantially above the patient's head. Alternately in some examples, a small projection screen may fold down from the module **10** and unfurl the projection screen adjacent and parallel to the anesthesia screen **30** substantially above the patient's head. Vital sign information projected on to the anesthesia screen **30** or small projection screen optimizes the simultaneous visualization of the patient and the monitors, in a single field of vision—much like a pilot's "heads-up" display.

As shown in FIG. **4**, in some examples the rear side **50** of the module **10** is roughly in the same vertical plane (or a plane parallel to or substantially parallel to) as the surgical drape **32** hanging down from the arm-board **26**, when the module **10** is located under the arm-board **26**. In this unique location, wires, cables and hoses can exit the sterile surgical field adjacent the surgical side **36** of the anesthesia screen **30** and drop substantially downward to be plugged into electrical plug-ins and air inlet vents **86** located on the rear side **50** of the module **10**. The wires, cables and hoses do not even have to touch the floor at that location. However, even if they do touch the floor, they do not cross any location where a surgeon would be standing, nor do they cross any walking pathway. In this unique location adjacent the surgical side **36** of the arm-board **26**, even wires, cables and hoses that are on the floor do not create a tripping hazard or an obstacle for small wheels. In some examples, a half pipe-shaped cable and hose cradle may be attached near the lower edge of the rear side **50** of the module **10**. Cables and hoses draping from the surgical field to the rear side **50** of module **10** may safely elevated off of the floor by laying in this half pipe-shaped cradle **51**. Locating module **10** adjacent to and under the arm-board **26**, allows this unique and safe access for wires, cables and hoses from the sterile surgical field.

In some examples, it may be preferable to locate the wire and cable plug-ins and the hose inlet vents **86** on the side **48** of the module **10** facing away from the patient. On this side, the electrical plug-ins and hose inlet vents **86** can be located higher on the module **10** for more convenient access by staff. When the plug-ins and connectors are located on the side **48** of the module **10** facing away from the patient, it is possible that the wires, cable and hoses may lay on the floor at the rear **50** of the module **10** and then rise to connect with the plug-ins and connectors. However, wires, cables and hoses laying on the floor directly adjacent to the rear side **50** of the module **10**, which is located under the arm-board **26** and surgical drape **32**, will not create an obstacle for standing or walking.

The inlet vents **86** can be located on any suitable surface of the module **10**, including under the bottom of the module **10** in order to collect air from near the floor. The inlet vents can include a flapper door or other suitable movable sealing device so that the vent stays closed unless a hose is plugged into the inlet vent **86**.

The equipment location illustrated in FIG. **4** is unique in the entire operating room from the perspective of safe wire, cable and hose management, exiting the surgical field. All other locations for surgical support equipment require that wires, cables and hoses exit the surgical field and traverse the floor between the surgical table **22** and the equipment. As a result, this creates a tripping hazard for personnel and obstacle for small wheels.

As shown in FIG. **4**, in some examples the rear side **50** of tower-like upper section **18** is directly adjacent the anesthesia screen **30**. The anesthesia screen **30** can include a sheet that separates the sterile surgical field from the non-sterile anesthesia work area. This exact location is uniquely the closest non-sterile location to the sterile surgical field. Nowhere else around the surgical table is any piece of non-sterile equipment this close to the sterile surgical field. In some examples the rear side **50** of the upper section **18** may be taller than the upper edge of the anesthesia screen **30**, therefore it is visible from or accessible from the surgical side, over the top of the anesthesia screen **30**. Since the rear side **50** of the upper section **18** may be directly adjacent the anesthesia screen **30**, it does not create any new flow-boundary layer obstructions to the ventilation airflow.

In some examples the rear side **50** of the upper section **18** is taller than the upper edge **31** of the anesthesia screen **30**. Therefore, the rear side **50** of the upper section **18** can be uniquely situated to mount various pieces of equipment that may be useful for the surgeon. For example, as shown in FIG. **23**, one or more surgical monitor screens **138** such as: patient vital sign monitor screens, surgical scope monitor screens, surgical check list monitor screens, safety check list monitor screens, communications and message monitor screens, clocks and timing device screens. In some examples the rear side of the upper section **18** may be uniquely useful for mounting a fan or surgical lights aiming at the surgical field.

As shown in the illustrative module **2310** of FIG. **23**, in some examples, a fan **134**A or **134**B is positioned to blow air from the head end of the sterile surgical field to the foot end. It is well known that moving air keeps suspended particles suspended. In contrast, suspended particles settle out of suspension in still, non-moving air. The ventilation airflow in the region between the surgeons standing on each side of the surgical table is frequently obstructed due to flow-boundary layers adjacent the surgeon's bodies (e.g., FIG. **21**A). Therefore, the ventilation airflow is prevented from flowing which allows airborne contaminating particles to settle into a surgical wound **114**. An airflow created by the fan **134**A or **134**B at the head end of the sterile field can prevent or reduce the air between the surgeons from becoming still and thus allowing settling.

A traditional surgical light is shaped like a disc and is generally about 24-36 inches in diameter. As shown in FIG. **23**, in some embodiments, a surgical light **135** of this disclosure may be shaped like a ring with a hole **139** passing through its middle and individual lights **137** located around the ring. The hole **139** in the middle of the light **135** may allow the ventilation airflow from the ceiling to pass through the surgical light **135**. Air passing through the middle of the ring-shaped light **134** eliminates the dead zone of no airflow that typically forms under flow obstructing disc-shaped surgical lights.

In some examples, the fan **134**A or **134**B can be located at the head end of the sterile field. The fan **134**A may be mounted in the hole passing through the ring-shaped light. From this location, the airflow from the fan **134**A may advantageously be aimed at the surgical wound when the light is aimed at the surgical wound **114** (FIGS. **21**A, **21**C).

As shown in the illustrative module **2410** of FIG. **24**, in some examples, the rear side **50** of the upper section **18** may be uniquely useful for mounting articulating arms that can "reach" across the upper edge of the anesthesia screen **30**, into the sterile surgical field and hold surgical lights, surgical instruments, surgical scopes or surgical retractors. Locating module **10** directly adjacent the anesthesia screen **30** uniquely allows access to the surgical field from the head end of the surgical table. Mounting surgical lights, surgical instruments, surgical scopes or surgical retractors to articulating arms that are attached to the rear side **50** of the upper section **18** obviates the need for attachment of this equipment to the side rails of the surgical table. This is especially useful because mounting the articulating arms to the side rail of the surgical table is difficult or even impossible when the patient and the side rail is fully covered by a surgical drape. In some examples, the articulating arms that can "reach" across the upper edge of the anesthesia screen **30** may be covered by custom sterile plastic drapes to prevent contamination of the sterile field. "Reaching" over the top (e.g., upper edge **31**) of the anesthesia screen both avoids the need for the side rail mounting and uniquely provides access to the surgery from the head end.

In some examples the rear side **50** of the upper section **18** is taller than the upper edge **31** of the anesthesia screen **30** and may be used as a mount one or more video cameras for recording the surgical procedure for: training and education purposes, inter operating room communication, communication with the family in the waiting room or video documentation for liability avoidance (much like police body cameras). In some examples a video camera mounted on the rear side **50** of the upper section **18** can show its image on one of the patient monitor display screens **38**A, **38**B, so that the anesthetist can view the surgical procedure without standing next to the anesthesia screen **30** and thus avoiding the disruption of the ventilation airflow caused by standing next to the anesthesia screen **30**. A view of the surgical procedure on the patient monitor display screens **38**A, **38**B would both improve the anesthetists' situational awareness and reduce airborne contamination of the sterile surgical field.

In some examples as shown in FIG. **25**, the rear side **50** of the upper section **18** may be taller than the upper edge **31** of the anesthesia screen **30** and may include a mount for a sterile storage container **132** for surgical supplies. The sterile storage container **132** may be accessed directly from the sterile field, reducing the time that the surgical team must wait for various sterile supplies. Negating the need for the circulating nurse to approach the sterile surgical field to deliver that given sterile supply also avoids the nurse kicking up contaminates off of the floor or disrupting the ventilation airflow during the supply delivery.

In some examples, as shown in FIG. **4**, the module **10** can include 4 or more sides (e.g., regions, side portions, faces). When positioned in the unique "no-man's land" under and adjacent the arm-board **26**, two of the sides **48** and **50** of module **10** are naturally available for surgical staff access and surgical equipment connections. In this position, two of the sides **44** and **46** of module **10** are naturally available for anesthesia staff access and anesthesia equipment connections. There is no other location in the operating room that can be advantageously "shared" by both anesthesia and surgery (two teams that do not historically share very well).

In some examples, the front face **44** of module **10** is substantially facing the anesthesia provider. Therefore, the front face **44** may naturally include controls and displays **38**A, **38**B for the anesthesia monitors and equipment. The front face **44** may also include plug-ins for certain equipment such as a heated clinician warming vest or specialty monitors. In some examples, the front face **44** includes a keyboard **56** and mouse pad for data entry. Other equipment such as IV bag pressurizers, IV pumps and drug infusion pumps may also be mounted on the front face **44** for convenient access by the anesthetist.

In some examples, the patient monitor display **38**A, **38**B and/or keyboard **56** (or other user input) may be mounted on swiveling brackets that allow side-to-side and/or up and down adjustment for improved viewing angles. In some examples, the patient monitor display **38**A, **38**B may be mounted on brackets that swing into a position even closer to the patient (lateral to the centered midpoint of the module **10**). From this unique location, the anesthetist has a very clear view of the monitor displays **38**A, **38**B in the same field of vision as the patient's head and the surgical field. No other monitor display **38**A, **38**B mounting location in the operating room can provide this simultaneous visual access to both the monitors **38**A, **38**B and the patient **24**. With the monitor display (e.g., screen) "aiming" at the anesthetist, an alarm light attached to the monitor display will also aim directly at the anesthetist, assuring that it will be noticed.

In some examples, the side **46** of the module **10** facing the patient **24** (e.g., as viewed in FIGS. **8-11**, **14** and **26**), can advantageously be used for its close proximity to the patient **24**. In some examples, wire, cable and hose management may be located on the side **46** facing the patient **24** (e.g. patient side of the module, patient face of the module). Most of these cables and hoses are for anesthesia purposes, including but not limited to electronic patient monitors, end-tidal carbon dioxide sampling, automated blood pressure monitors, electrically heated blankets and mattresses and waste oxygen scavenging and dilution.

In some examples, cables and hoses for surgical equipment may be advantageously managed from the side **46** of the module **10** facing the patient **24**. Examples include but are not limited to air mattresses, pressure sensing mats, sequential compression leggings, capacitive coupling electrosurgical grounding electrodes and RFID antennae for detecting retained surgical items.

In some examples, the module **10** also includes a hanger **144** for holding and securing a urine bag **140** off of the floor. In some examples, and as shown in FIG. **26**, the urine bag hanger **144** may be advantageously mounted on side **46** of the bulbous lower section **16** facing the patient **24**. From this position, the urine bag tubing **142** can easily reach the module **10** from the sterile field or from under the surgical table, without traversing or touching the floor. From this position, the urine bag **140** can conveniently be accessed by the anesthetist from the front face **44** of the module. In some examples, the urine bag hanger **144** can include a hook-like element. In some examples, other urine bag hanger **144** elements including but not limited to, clips, straps, snaps or Velcro, or any other suitable attachment mechanism may be provided

In some examples, the urine bag hanger **144** is attached to a scale **145** for measuring the weight of the urine bag **140** plus the weight of the urine in the bag. Measuring the weight of the urine is far more accurate than the traditional method of visually measuring the volume of urine in a collapsible plastic urine bag **140**. Since urine has virtually the same specific gravity as water, each 1 gram of urine weight equates to 1 ml of urine volume.

In some examples, the urine bag hanger **144** is attached to an electronic scale **145** for measuring the weight of the urine bag **140** plus the urine in the bag. In some examples, the digital output of the electronic scale **145** that is attached to urine bag hanger **144** is directly reported on a patient monitor display **38**A or **38**B. In some examples, the electronic output of the electronic scale **145** that is attached to urine bag hanger **144** (e.g., generated sensor data) is digitalized and received by the processor that is programed to record the beginning weight of the urine bag (the weight of the urine bag plus any urine already in the bag) and automatically subtract that beginning weight from subsequent recorded urine bag weights, calculate the urine output during surgery. In some examples, the electronic output of the electronic scale **145** is digitized and reported (e.g., generated and a signal sent) to a processor (e.g., processing circuitry **157**) In some examples, the total urine output and in some cases urine output per hour determined by the processor, are then displayed on a patient monitor display **38**A or **38**B. In some examples, the total urine output and in some cases urine output per hour determined by the processor, may be automatically recorded in the electronic anesthetic record, a non-transitory computer readable medium. Including an electronic scale attached to urine bag hanger **144** conveniently obviates the need to empty the urine bag **140** at the beginning of the operation in order to "zero" the system, as is traditional with a visual urine measuring system. The electronic scale **145** allows the beginning weight of the urine bag plus any urine already in the bag to be easily subtracted from the running weight (e.g., The processor can calculate a zero point). Time measurements do not need to be limited to per hour measurements, any unit of time, such as per minute, or per second, may be used. In some examples, a urine measurement per surgery can be displayed or saved.

To perform determinations and calculations and take action, the processor can receive and processor signals (including sensor data and other input data) and can generate signals that are communicated to a controller that is operably coupled to the processor. The controller can include one or more control modules, for example electronic control modules (ECMs), electronic control units (ECUs) and the like. The one or more control modules may include processing units, memory, sensor interfaces, and/or control signal interfaces for receiving and transmitting signals. The processor may represent one or more logic and/or processing components used by the control module to perform certain communications, control, and/or diagnostic functions. For example, the processing components may be adapted to execute routing information among devices within and/or external to the control module.

In some examples, the urine bag **140** may include an inlet near its top for attaching a vacuum or suction hose from the module **10**. In some examples, a hydrophobic, air-permeable membrane may be added to the proximal end of the urine bag tubing **142**, near the patient's catheter. Introducing a mild vacuum in the urine bag **140** pulls air through the hydrophobic, air-permeable membrane into the urine bag tubing **142**. The resulting air bubble in the urine bag tubing **142** near the patient end of the tubing, is pulled to the urine bag **140** by the vacuum. The moving air bubble breaks any air "vapor locks" that may have formed in the urine bag tubing **142** and that may be obstructing the flow of urine through the urine bag tubing **142**, allowing free flow of the urine into the urine bag **140**.

In some examples, and as shown in FIG. **4**, the rear side **50** of the module **10** is open to the surgical side **36** of the anesthesia screen **30**, below the surgical drape **32** hanging down from the arm-board **26**. From this location, the rear side **50** can be accessed directly for plugging in wires, cables and hoses exiting the sterile surgical field. However, the low height of the access, below the lower edge of the surgical drape, may be considered to be inconvenient.

In some examples, the side **48** of module **10** facing away from the patient **24** may be advantageously accessed by the surgical nurse without encroaching on the anesthetist, the anesthetist's space or the anesthesia side **34** of the anesthesia screen **30**. In some examples, the side **48** facing away from the patient **24** may include the controls and display screens **120** for surgical equipment (e.g., surgical support equipment) contained within the module **10**. This surgical equipment includes but is not limited to: an electrosurgical unit, an air mattress, a pressure sensing mat, a smoke evacuation unit, a dead-zone evacuation system, blood and fluid suction and disposal, sequential compression leggings and an RFID surgical sponge and instrument counting and detection system.

In some examples, most of the surgical support equipment may be incorporated into module **10**, which allows the surgical nurse or technician to monitor and control all of this equipment from a single location—the side **48** of the module **10** facing away from the patient **24**. The consolidated surgical equipment controls and displays **120** become very efficient for the nurse to monitor compared to having the equipment scattered all over the operating room. This is also far more likely that problems will be noticed early than if the individual pieces of equipment are scattered all over the operating room as is the current practice. Efficient monitoring also means that patient safety is improved. In some examples, the displays and controls **120** for the surgical equipment may be located on the front face **44** of the module **10**, or another face of the module.

In some examples, the controls and display screens for the surgical equipment housed in the module **10** may be wirelessly connected to a portable display screen such as an iPad or "smart tablet," for convenient access by the nurse anywhere in the room. This allows the surgical nurse to monitor and control the equipment without walking across the room. Minimizing surgical staff movement in the OR has been shown to reduce airborne contamination and surgical site infections because less contaminates are "kicked up" by walking around the OR.

In this unique location adjacent the arm-board **26**, the various sides **44**, **46**, **48**, **50** of module **10** are naturally and advantageously adapted for different functions. The rear side **50** and the side **48** facing away from the patient can be adapted for surgical purposes. The front side **44** and the side **46** facing the patient can be adapted for anesthesia purposes. The only place that this unique combination could be achieved is in the currently unoccupied "no-man's land" between the anesthesia **34** and surgical sides **36** of the operating room—the anesthesia screen **30** and arm-board **26**. The module **10** is uniquely adapted to advantageously fit this location.

As described herein, sides (e.g., faces) **44**, **46**, **48**, **50** can be distinct sides as in the planar sides of a rectangular cuboid shape, or another cuboid shape. In some examples, the faces can include any shape including non-cuboid shapes having more than 4 outward facing sides accessible to medical personnel.

However, in other examples the sides can refer to side portions of a curved or irregular shaped volume. In some examples, the sides can refer to an approximately 90 degree or quarter span of the volume that forms the module **10**.

In some examples, as shown in FIGS. **4-7**, the module **10** includes a lower section **14** and an upper section **18**. In general, the lower section **14** may contain the heavier equipment such as one or more power supplies **212**, the electro-surgical unit and monitor electronics. In general, the upper section **18** may contain lighter equipment and components such as ducting, fans, filters, cable management systems, wiring harnesses and monitoring screens **38**A, **38**B. Keeping the heavy equipment in the lower section **14** improves the stability and reduces the risk of tipping.

In some examples, and as shown in FIGS. **4-6**, the lower section **14** could be called a bulbous lower section **16**. "Bulbous" is compared to the upper section **18**. There are several advantages for the lower section **16** being "bulbous." The bulbous lower section **16** has an increased internal volume that can house much more equipment. The bulbous lower section **16** efficiently utilizes the otherwise wasted space under the arm-board **26**. The bulbous lower section **16** substantially increases the footprint of the base of module **10**, allowing the rear wheels to be much further to the rear of the module, substantially increasing the stability of the module **10**. Heavier equipment may be located toward the rear of the bulbous lower section **16**, which further increases the stability and lessens the likelihood of module **10** tipping forward.

In some examples, the bulbous lower section **16** may be of any size. In some examples, a cube roughly 24 inches on each side can fit under the arm-board **26**. Other sizes and shapes are anticipated. A 24 inch cube may appear to be rather large and cumbersome, but it is worth noting that the standard 5-wheeled base for an IV pole **42** is an area roughly 24 inches in diameter. Therefore, the floor occupied by and the traffic patterns affected by the 24 inch square of the bulbous lower section **16**, is virtually identical to the 24 inch diameter circle of the current IV pole **42** that can sometimes be located in that same position. However, the volume above an IV pole base is wasted in contrast to the bulbous lower section **16** which may include 8 cubic feet or more, of volume that can house various surgical and anesthetic equipment. The bulbous lower section **16** very efficiently utilizes otherwise wasted volume under and adjacent to the arm-board **26**. In some examples the bulbous lower section may include between 4 and 12 cubic feet of volume. In a possibly more preferred example, the bulbous lower section **16** may include between 6 and 10 cubic feet of volume.

In some examples, the bulbous lower section **16** may include standardized 19" electronic component racks. In this case, the modular electronic and electromechanical components stored in the bulbous lower section **16** can be easily added or removed. For the standardized 19" electronic component rack systems to work, the various pieces of electronic and electromechanical anesthesia and surgical equipment to be relocated into the module **10**, will need to be reconfigured to fit the standardized 19" electronic component rack.

In some examples, the module **10** may be additionally stabilized and prevented from tipping by suctioning the module to the floor of the OR. The floors of most ORs are very smooth and polished, with no crevasses that can collect contaminates. This creates an ideal surface for creating a vacuum in a suction cup. In some examples, instead of or in conjunction with wheels **52**, one or more suction cups **53**, much like the suction cups for handling large glass panes, may be extended downward from the bottom of module **10** to engage with the floor. In some examples, when the module **10** has been positioned properly, one or more actuator pneumatic cylinders or electromechanical mechanisms may be triggered to lower the one or more suction cups **53** until they contact the floor. In some examples, the actuator can be a hand-powered or manually actuated actuator. In some examples the actuator can be electronically controlled by processing circuitry receiving instructions from an indictor such as a switch or touch screen element. A vacuum is then applied to the one or more suction cups **53**. The vacuum can be applied, for example, by the hospital vacuum system or from a vacuum pump located within the module **10**. When the module **10** is suctioned to the floor, it will exhibit significantly more stability and be less likely to tip or move than a similar module left freestanding. In other words, the suction cups can create a suction coupling with the floor.

The vacuum can be applied to the suction cups at a discrete point in time, intermittently or continuously. In the suction cups that are for handling large glass panes, the vacuum is generally created with a single discrete lever action. In contrast, in some examples, the vacuum in the present disclosure may be continuously applied by connecting the suction cup to the hospital vacuum system or the vacuum system in module **10**. A continuous vacuum supply may be advantageous over a single vacuum application when there is dust, lint or dirt on the floor that may foul the seal of the suction cup, making it leak air and slowly lose its vacuum. A continuous vacuum supply can overcome a slow air leak. To decouple the module **10** from the floor, the vacuum can be released and the suction cups elevated off of the floor by the one or more actuator pneumatic cylinders, electromechanical mechanisms or hand-powered actuators, before the module **10** can be moved.

In some examples, as shown in FIG. **7**, the lower section **14** may not be bulbous. In some examples, the lower section **14** may be designed to fit adjacent the arm-board **26** but may not go under the arm-board **26**. In some examples, the lower section **14** may fit minimally under the arm-board **26**. In this instance, the space under the arm-board **26** may be utilized for stability by adding short legs **54** extending rearward to mount castor wheels further rearward. Even if the volume under the arm-board **26** is not utilized for equipment storage, the volume adjacent the arm-board **26** may be efficiently utilized for storing equipment in the lower section **14** of the module **10**.

In some examples, the module **10** of can include a shell or "cowling" **12** covering substantially the entire outer surface. Open equipment racks with various pieces of equipment stacked on their shelves that remain open and exposed must be kept at a safe distance from the surgical table **22**. In contrast, creating an enclosed module **10** for storing various unrelated pieces of equipment is unique in the operating room. Creating an enclosed module **10** for storing various unrelated pieces of equipment makes it possible to place the module **10** near the surgical table **22** during a surgery. The cowling **12** can protect the equipment in the module **10** from accidental fluid damage by IV fluids, irrigation fluids and blood. Any equipment on an open rack adjacent and under the arm-board **26**, may be at high risk for damage from water, saltwater and blood in this hazardous environment.

In some examples, the cowling **12** of module **10** is made of molded plastic, 3-D printed plastic, molded fiberglass, aluminum, steel or other suitable materials. In some examples, the cowling **12** may preferably be fluid resistant if not fluid proof. In some examples, the cowling **12** can be shaped so that water naturally runs off of it and that it has smooth surfaces for easy cleaning. In some examples, any air inlet vents can include overhangs that protect them from fluid ingress from spilled fluids and the access ports of the cowling **12** may preferably be sealed when closed, to prevent fluid ingress.

In some examples, the cowling **12** of module **10** confines the waste heat from the electronic and electromechanical equipment mounted within the module **10**, to the inside of the module **10** and cowling **12**. In some examples, the confined waste heat can then be safely managed. Confining waste heat from unrelated equipment can be the first step in safely managing the waste heat. Waste heat can only be confined and captured for processing if there is a relatively air-impermeable cowling **12** surrounding the equipment. It is difficult or even impossible to manage the unconfined waste heat produced by electronic and electromechanical equipment mounted on a simple open rack or free-standing in the middle of the operating room floor.

In some examples, the cowling cover of the module **10** described herein contributes to a waste heat management system. The cowling **12** can substantially seal in the waste heat and control the discharge of the waste heat to exit at a predetermined location, such as an outlet vent. In some examples as shown at least in FIGS. **1**, **4** and **7-12**, the module **10** can include a tower-like upper section **20** attached to or integrally formed with the topside of the lower section **14**. In some examples, the tower-like upper section **20** extends substantially vertically from the topside, near the front of the lower section **14**. In some examples, the cowling **12** of the tower-like upper section **20** serves as a chimney, containing the rising waste heat until it can be safely discharged from outlet vents located near the top of the tower.

In some examples, the top of the tower-like upper section **20** is 5 feet or more above the operating room floor. At this height, waste heat exhausted from vents near the top of the tower-like upper section **20** is vented into the operating room well above the height of most airborne contaminates. In some examples, air is allowed to enter the module **10** through inlet vents **86** (FIGS. **4**, **16**, **17**) in the lower section **14**, the air gets heated by the electronic and electromechanical equipment in the module **10** and then by natural convection, the heated air may rise within the tower-like upper section **20** and be discharged through outlet vents near the top of module **10**.

In some examples, the air discharge can occur at a height between 3 and 12 feet above the floor that the module **10** is configured to rest on. In a preferred example, the air discharge can occur at a height of at least 4 feet off the floor. In a more preferred example, the air discharge can occur at a height of at least 5 feet off the floor. In some examples, the air discharge can be connected to an OR venting system which removes the discharged air from the OR.

In some examples, a filter and fan may be added to the waste heat management system in order to filter the waste heated air before discharging it into the operating room, or to filter inlet air. The resistance to airflow caused by adding a filter to the airflow path may necessitate adding a fan to the waste heat management system. In some examples, a sock-like filter may be added to the outlet vent in order to diffuse the outlet air and muffle any fan noise.

In some examples, the inlet vents for the cooling air may be located in the tower-like upper section **20**, four or more feet above the floor, above the level of the airborne contamination. At this level, the inlet air is relatively pure and therefore there is no risk of contaminated air causing contamination of the equipment housed within the module **10**. In some examples, a duct may connect the inlet vent in the tower-like upper section **20** to the equipment space in the lower section **14**. The clean inlet air can be drawn into inlet vents mounted high on the upper section **18** and then ducted down to the equipment that needs cooling and then ducted back up to the tower **20** to be discharged at a safe height above the airborne contaminates. In some examples, ionized air filter plates may be included in the ducting to provide added filtration of the air without added resistance to the airflow.

In some examples, the lower section **14** includes castor wheels **52**. The castor wheels **52** may be located substantially in the four corners of the lower section **14**. In some examples, the lower section may include more than 4 castor wheels. In some examples, and as shown in FIG. **7**, the lower section **14** may include short "legs" **54** that stick 2-10 inches out from the perimeter of the base of the lower section **14**. Castor wheels **52** may be attached near the distal ends of these short legs **54** to improve the stability of the module **10**.

In some examples, the module **10** does not have wheels but is rather mounted to a movable boom hanging from the ceiling of the operating room. The boom can include two or more arms that articulate and are attached to a pivot point on the ceiling. This configuration allows the module **10** which is attached to the end of the boom, to be moved into a position adjacent the arm-board **26** and then moved away from that position, if for example a gurney needs to be placed against the side of the surgical table. In some examples, even the boom-mounted modules **10** advantageously include bulbous lower sections **16** to maximally capitalize on the wasted volume under the arm-board **26**. In some examples, booms from the ceiling may advantageously include power cords, communication cables, air, oxygen and vacuum hoses that conveniently connect outlets in the ceiling to the module **10**.

In some examples, the module **10** includes an upper section **18** as shown in FIGS. **4-7**. In general, the upper section **18** is for housing or mounting lighter equipment and locating controls **120** and monitor displays **38**A, **38**B at a height where they can be conveniently accessed. In some examples, the upper section **18** may be a tower-like upper section **20** as shown in FIGS. **4** and **7**. In this instance the top of the tower-like upper section **20** may be more than 4 feet above the floor. In some examples, the top of the tower-like upper section **20** may advantageously be 6 feet or more above the floor.

Using the example modules **10** described herein, heat and air can be more safely discharged at higher heights in the operating room because the heat discharged at that height cannot mobilize contaminates that normally reside near the floor. Therefore, a taller tower-like upper section **20** may advantageous.

In some examples, a patient monitor display **38**A, **38**B may be mounted on the rear of the tower-like upper section **20** of the module **10**, facing the surgeon. In this unique location, viewable over the top of the anesthesia screen **30**, the surgeon **108** can be constantly aware of the patient's vital signs.

In some examples, the upper section **18** of module **610** may be a medium height, for example 3-4 feet above the floor as shown in FIG. **6**. In some examples, the upper section **20** may be a relatively low height of 2-3 feet above the floor as shown in FIG. **5**. In each case, the upper section **18** places the controls **120** and monitor displays **38**A, **38**B for the equipment can be enclosed in the module **510** or **610**, at a more convenient height for the operator. FIG. **5** also illustrates a tank **214** disposed in (or on) the module **610**. Illustrative tank **214** can supply any of the anesthesia gasses, pressurized air or vacuum etc., as described herein.

In some examples, patient monitor display screens **38**A, **38**B may be mounted on one or more sides (e.g., faces, side portions) of the upper section **18** of module **10** as shown in FIGS. **4** and **7**. In some examples, the patient monitor display screens **38**A, **38**B may be mounted on arms that attach to the top of the upper section **18** as shown in FIG. **6**. In some examples, a keyboard **56** and/or mouse pad may also be mounted to the upper section **18** of module **10** (FIG. **4**).

In some examples, upper section **18** includes a side **46** facing the patient. In some examples, if the upper section **18** is tower-like, the side **46** facing the patient is a relatively large surface area. For example, the side **46** facing the patient may be 12 inches wide (or more) and 48 inches tall (or more) which results in 4 square feet of surface area on the side **46** of the upper section **18**. This large surface near the patient and facing the patient is uniquely located and sized for a cable and hose management system **58**.

In some examples, and as shown in illustrative module **810** of FIG. **8**, the cable and hose management system **58** may comprise one or more straps **70** mounted on the side **46** facing the patient (e.g., configured to face the patient, configured to face the surgical table). In some examples, there may be an array of 3-15 straps **70**. Each strap **70** may retain an individual cable or hose. These straps **70** may include a snap, Velcro or other closures means **72** in order to create an openable loop that can retain a coiled cable or hose.

In some examples, as shown in illustrative module **910** of FIG. **9**, the cable and hose management system **58** may comprise one or more hooks **74** mounted on the side **46** facing the patient. In some examples, there may be an array of 3-15 hooks **74**. Each hook **74** may retain an individual cable or hose.

In some examples, as shown in illustrative module **1010** of FIG. **10**, the cable and hose management system **58** may comprise one or more reels **76** mounted on the side **46** facing the patient. In some examples, there may be an array of 3-15 reels **76**. Each reel **76** may retain an individual cable or hose. These reels **76** may be used to wind the cables and hoses on to a spool for secure storage. The reels **76** may be manually operated, spring powered or powered by electric motors.

In some examples, and as shown in illustrative module **1110** in FIG. **11**, the cable management system can include cables that are naturally coiled during the molding process of the outer insulation, somewhat like the traditional telephone cord. In some examples, the coils **60** of cable or hose may be much larger than the traditional telephone cord. As shown in FIGS. **12** and **13**, coils **60** that are 2-5 inches in diameter, much like a "slinky" may be preferable. Coils **60** of larger diameter may have superior "memory" to retain the coiled shape. Electrical insulation materials such as urethane and nylon also provide superior "memory" characteristics compared to the PVC coating historically used for telephone cords.

As shown in FIG. **14**, these larger coils **60** are easily stretched because the elongation is accomplished primarily by the lateral movement of adjacent coils, perpendicular to the plane of the individual coils, basically elongating the tubular shape, a movement that is minimally opposed by the "memory" of the molding process. This is in contrast to an attempt to unwind each of the individual coils **60**, a movement that is maximally opposed by the "memory" of the molding process. The larger coils **60** easily stretch laterally between each adjacent coil **60** and stretch minimally in the plane of each coil **60**. This is identical to the principals the make a "slinky" work, very easy to stretch in the direction of the coiled tube but nearly impossible to unwind an individual coil. The larger coils **60** easily stretch laterally between each adjacent coil **60** which makes them far less prone to twisting and tangling than if an individual coil **60** is "unwound."

In some examples the coils **60** of the cable management system **58** are created by extrusion molding an electrically insulating plastic sheath over the wires of the cable. In some examples the coils **60** of the cable management system **58** are created by extrusion molding a coil of plastic tubing **80** and then inserting the wires of the cable **78** into the tubing **80** as a second operation. In some examples, when tubing **80** is used to create the coils **60**, the tubing **80** may be 0.25-0.6 inches in outside diameter. Larger tubing **80** diameters may work better with larger coil **60** diameters. In some examples the preferred tubing material is urethane. Any other suitable tubing materials may be used, including but not limited to nylon and PVC.

There are several advantages to adding a cable **78** to a molded coil **60** of plastic tubing **80** as a second process rather than molding the insulation layer of the cable into a coiled shape. The extruded tubing **80** has a thicker outer layer of very uniform extrusion thickness, which results in a more durable outer layer with superior memory for the coiled shape **60**. The diameter of the tubing **80** may be significantly greater than an equivalent diameter of extruded cable insulation. The greater diameter of the tubing **80** accentuates the principle that makes a "slinky" work, very easy to stretch in the direction of the coiled tube but difficult to unwind an individual coil **60**.

In some examples, one construction is to add 0.5-4 feet of standard cable **78** to the distal end of the coiled tubing **80** and pull the individual wires through the coiled tubing **80** to the proximal end of the tubing **80**. In this case, the distal 0.5-4 feet may be a much more flexible cable **78** than the coiled tubing **80** because the cable **78** is not intended to retain a memory for a coiled shape. The tubing **80** and the cable **78** may be made of different materials, or different durometers of the same material, or different stiffness's of the same material for their outer insulation layers, each of which optimize the intended function (coil memory vs. flexibility). The wall thickness of the tubing **80** can also be adjusted to optimize coil memory vs. flexibility.

The 0.5-4 feet of standard cable **78** attached to the distal end of the coiled tubing **80** also presents a lower profile as it encounters the patient. For example, if the cable **78** is an EKG lead laying on top of the patient's chest, a flexible non-coiled wire or cable **78** can be more comfortable than coiled tubing **80**.

In some examples, this design optimizes the recoil function at the proximal coiled tubing **80** portion of the cable. This design also optimizes the patient interface for flexibility, low profile and comfort by transitioning from the coiled tubing **80** to a standard cable **78** for the distal 0.5-4 feet.

In some examples as shown in FIGS. **12** and **13**, the proximal end **62** of the proximal coil **60** is firmly attached to the side **46** of the module (e.g., **1110**, FIG. **11**) facing the patient, in order to prevent the tubing **80** from twisting when removed from the storage bracket **66**. In some examples, the firm non-twisting attachment may preferably orient the plane of the first coil **60** and thus the planes of all of the coils **60**, essentially parallel to the plane of side **46**. Orientation of the first coil **60** to be parallel to the plane of side **46** makes the entire stack of coils **60** naturally form into a tubular or stack shape for easy storage. In some examples, a storage bracket **66** protrudes from the side **46** to provide a storage location for the naturally coiled tubing **80** cables and hoses. The natural coiled shape makes loading the tubular stack of coils **60** onto the storage bracket **66** so easy that it almost occurs spontaneously.

In some examples as shown in FIGS. **12**, **13** and **15**, the storage bracket **66** may include a retaining lip **68** that helps to prevent the coils **60** from inadvertently slipping off of the storage bracket **66**. In some examples as shown in FIG. **15**, the retaining lip **68** may also advantageously allow one or more individual coils **60** to be removed from the storage bracket **66** while retaining the remaining coils **60**. This conveniently allows variable lengths of tubing, cables and hoses to be extended from the cable and hose management system **58**. Cables and hoses that need to reach further, for example to the foot of the surgical table or to the arm-board on the opposite side of the surgical table, may require all of the coils **60** to be removed from the storage bracket **66** and stretched to their limits. Alternately, if a given cable or hose is only traveling a short distance, for example to the patient's chest or the head end of the mattress, perhaps only one or two individual coils **60** may be removed from storage bracket **66** and the remaining coils **60** are retained on the bracket **66**. This minimizes the excess cable and hose from cluttering and tangling.

In some examples, with minimal force six, 3-inch diameter coils **60** of this invention can be stretched perpendicularly to the plane of the individual coils **60**, a distance of more than 4 feet. In the stretched configuration, the coils **60** may preferably still exhibit recoil forces but the recoil forces are not so great as to pull the plug or sensor **82** loose from the patient connection.

The recoil of the molded coils **60** naturally cause the adjacent individual coils **60** to form into an orderly stack or tubular shape which can easily be loaded onto the storage bracket **66**. Storing the stack of individual coils **60** on a storage bracket **66** helps the individual coils **60** and the stack of coils **60** "rest" and thus may retain their molded "memory" for a coiled shape over years of use.

In some examples, the natural recoil of the coils **60** can advantageously prevent the electrical plug **82** or hose connector from touching the floor when not loaded on the storage bracket **66** and not in use. The natural recoil of the coils **60** may advantageously prevent the plug **82** or hose connector from touching the floor even if the coiled tubing **80**, cable **78** or hose is not properly stored on the storage bracket **66**. Keeping cables **78** and hoses off of the floor vastly reduces their contamination and need for cleaning. This is in contrast to the current cable and hose situation in the OR, where they typically lay on the floor when not in use.

In some examples the cable and hose management system **58** using coiled tubing **80** may be adapted to a location that is remote to the module **10**. In some examples the cable and hose management system **58** using coiled tubing **80** may be adapted to the outer shell or case of another piece of equipment such as a patient warming system or a patient monitor.

In some examples, and as shown in FIGS. **27**, the cable and hose management system **58** (e.g., FIGS. **8-15**), rather than being included in module (e.g., **10** and example variants of **10**), may be adapted to be a free-standing distribution pod **146**A that may be attached to the side of the surgical table **22** and may be used to distribute and connect the distal end of the wires contained in a trunk cable **148**, to the patient **24** and surgical table **22**. In some examples the cable and hose management system **58** adapted to a free-standing distribution pod **146**A includes coiled cables **60**, coiled tubing **80**, cables **78**, mounting and storage brackets **66** previously described that may be advantageously used to store the cables and hoses for various surgical and anesthetic equipment and monitors in a convenient location immediately adjacent the patient (e.g., FIGS. **8-15**). Attaching the free-standing distribution pod **146**A to the side rail of the surgical table **22**, locates the pod **146**A as close to the patient as possible keeping cable and hose lengths reaching to the patient as short as physically possible. Short hoses and cables result in less tangling, less chance of laying on the floor and are easier to clean and store.

In some examples the cable and hose management system **58** adapted to a free-standing distribution pod **146**A, is attached to one end of a trunk cable **148** and the other end of the trunk cable may be attached to any electronic or electrical equipment including but not limited to: the module **10**, a patient warming controller, a patient monitor, air mattress controls, an electrosurgical generator, an automated blood pressure monitor or sequential compression legging controls. The trunk cable combines all of the wires from the individual cables into a single multi-wire cable in order to reduce the number of wires that can tangle and require cleaning.

In some examples, the free-standing distribution pod **146**A includes a substantially waterproof shell **150**. In some examples the distribution pod **146**A, like the module **10**, can include a fluid-resistant or heat confining cowling. In addition to the trunk cable **148**, the inputs and outputs to the shell **150** of distribution pod **146**A include but are not limited to: coiled cables **60**, coiled tubing **80**, cables **78**, electrical plug-ins **152**, air hose and vacuum hose connectors. In some examples, the free-standing distribution pod **146**A may include air pumps, vacuum pumps and monitor electronics housed in the shell **150**.

In some examples, the free-standing distribution pod **146**A may be attached to the proximal end of a second trunk cable, the distal end of which may be attached to a second free-standing distribution pod (e.g., a second one of **146**A). In effect, the two distribution pods **146**A may be "daisy chained" together via the second trunk cable and in this case the first trunk cable **148** includes the combined wires for both distribution pods **146**A, connecting back to the originating electronic and electrical equipment. In some examples for example, the second free-standing distribution pod **146**A may distribute the cables and hoses that connect the patient to the patient monitors. In this case the first free-standing distribution pod **146**A may distribute the cables connecting the patient warming blankets and mattresses to the patient warming controller. The second trunk cable may also include electrical power to the second free-standing distribution pod **146**A for powering various electronics and pumps that may be housed within its shell **150**.

In some examples, the free-standing distribution pod **146**A or other pieces of surgical equipment, may be removably attached to one of the rails **174** that run along the sides of the surgical table **22**. FIG. **32**A shows another example of a distribution pod **146**B that can include all the features of distribution pod **146**A and vice-versa. As shown in FIG. **32**A, the attachment mechanism for removably attaching the distribution pod **146**B to one of the rails **174** may comprise a metal plate **176**, mounted on the back side of the distribution pod **146**B. The upper edge **178** of the metal plate **176** may be bent into a generally "hooked" shape for hanging on the side rail **174**. In some examples, the upper edge **178** may be attached to a "side rail" element that is included in the module **10**.

In some examples, and as shown in FIG. **32**A, the generally "hooked" shape of the upper edge **178** of the metal plate **176** may be formed by bending the metal plate **176** twice. In some examples, the first bend **180** in metal plate **176**, nearest the mounting to the back side of the distribution pod **146**B or other pieces of surgical equipment, may create a first angle **194** of greater than 90° between the metal plate **176** and the top of the "hook" **184**. In some examples, the first bend **180** in metal plate **176**, nearest the mounting to the back side of the distribution pod **146**B or other pieces of surgical equipment, may create an angle of 95° to 135° between the metal plate **176** and the top of the "hook" **184**. In some examples, the second bend **182** in metal plate **176** creates the retaining lip portion **186** of the generally "hooked" shape **184**, may create a second angle **196** of approximately 90° between the top of the "hook" **184** and the retaining lip portion **186**. In some examples, the distance between first bend **180** in metal plate **176** and the second bend **182** as measured on the inside of the "hook" **184**, may be equal or slightly more than the width of the rail **174**. The standard width of rail **174** is ⅜".

In some examples, one or more retainer tabs **188** are located slightly more than one rail height below the first bend **180** in metal plate **176**. The standard height of rail **174** is 1⅛". The retainer tabs **188** may be formed by bending the metal plate **176** along a vertical axis. In some examples, the retainer tabs **188** may be located near the lateral edges of metal plate **176**. In some examples, the retainer tab **188** may be formed by welding or attaching an added piece of metal to protrude from the back side of metal plate **176**.

In some examples, the first bend **180** creating an angle of greater than 90° between the metal plate **176** and the top of the "hook" **184** and the second bend **182** creating an angle of approximately 90° between the top of the "hook" **184** and the retaining lip portion **186**, allows the retaining lip portion **186** to be angled outward relative to the plane of metal plate **176**. As shown in FIG. **32**B, the outward angle of the retaining lip portion **186** allows the bottom portion of the distribution pod **146**B or other pieces of surgical equipment to be pivoted away from the side of the surgical table **22** while the retaining lip portion **186** initially engages rail **174**.

In this orientation one or more retainer tabs **188** clear the outer side of rail **174** while the rail **174** is engaging the "hook" **184**. As shown in FIG. **32**C, the bottom portion of the distribution pod **146**B or other pieces of surgical equipment are then rotated toward the side of the surgical table **22**, engaging retainer tabs **188** under the rail **174**. The snug fit of retainer tabs **188** under the rail **174** secures the distribution pod **146**B or other pieces of surgical equipment to the rail **174**. The snug fit of retainer tabs **188** under the rail **174** is allowed because the first bend **180** creates an angle of greater than 90° between the metal plate **176** and the top of the "hook" **184**, and becomes the axis of rotation against the upper, outer angle **190** of rail **174**, when the distribution pod **146**B or other pieces of surgical equipment are rotated toward the side of the surgical table, engaging retainer tabs **188** under the rail **174**. Therefore, the distance between the first bend **180** and the top of the retainer tabs **188** can be exactly the height of the rail **174**, in order to create a snug fit between retainer tabs **188** underside of rail **174**.

In contrast, when both the first bend **180** and the second bend **182** create angles of approximately 90°, the distance between the bends have to be much greater than the width of the rail **174** in order to allow distribution pod **146**B or other pieces of surgical equipment to be angled away from the side of the surgical table, allowing retainer tabs **188** to clear the outer side of rail **174**, while the rail **174** is engaging the "hook" **184** during mounting. Additionally, when both the first bend **180** and the second bend **182** created angles of approximately 90°, the axis of rotation during the rotation of the distribution pod **146**B or other pieces of surgical equipment toward the side of the surgical table **22**, would be somewhere between first bend **180** and the second bend **182** and the axis of rotation would against the upper, inner angle **192** of rail **174**. In this arrangement, the first bend **180** has to be elevated off the upper surface of rail **174** when the distribution pod **146**B or other pieces of surgical equipment are rotated away from the side of the surgical table **22**. With this unfavorable axis of rotation, the distance between the first bend **180** and the top of the retainer tabs **188** may have to be significantly greater than the height of the rail **174**, in order for retainer tabs **188** to rotate under the rail **174**. When the distance between the first bend **180** and the top of the retainer tabs **188** is significantly greater than the height of the rail **174**, the retainer tabs **188** can fail to snuggly and securely attach the distribution pod **146**B or other pieces of surgical equipment to the rail **174**.

In some examples, the simple but secure attachment of the distribution pod **146**B or other pieces of surgical equipment to rail **174**, can prevent accidental detachment, falling and damage to the equipment. Detachment of the distribution pod **146**B or other pieces of surgical equipment from rail **174** is accomplished by rotating the bottom portion of the distribution pod **146**B or other pieces of surgical equipment outward, away from the side of the surgical table **22**, which disengages the retainer tabs **188** from under the rail **174**. Then lifting the distribution pod **146**B to disengage the "hook" **184** from the rail **174**.

Traditionally, electric power cords, air hoses, oxygen hoses, vacuum hoses and communications wires hanging from the ceiling of the OR, disrupt workflow and create hazards to personnel movement when not hooked to their intended equipment. Traditionally, electric power cords, air hoses, oxygen hoses, vacuum hoses and communications wires hanging from the ceiling of the OR are limited in length so as to not touch the floor when hanging free. This limited length severely limits the movement and flexibility of location for the anesthesia gas machine or any other any other equipment to which they may be hooked. The gas machine must be located directly below the ceiling outlets. In some examples, power cords, communication cables, air, oxygen and vacuum hoses from the ceiling can be more safely and unobtrusively connected to the top of a taller tower-like upper section **20**.

In some examples, power cords, air hoses, oxygen hoses, vacuum hoses and communications wires are coiled similarly to coils of the cable management system **58** disclosed herein. In some examples, the coils are created by extrusion molding a coil of plastic tubing and then inserting the wires of the cable or cord into the tubing as a second operation. In some examples, the coils are created by extrusion molding a coil of plastic tubing for air hoses, oxygen hoses and vacuum hoses. In some examples, the coiled plastic tubing portion comprises the proximal end of the cable or hose, the end attached to the ceiling. The coiled tubing may be any length but may preferably be 6-16 feet when stretched in some examples.

In some examples, nylon may be the preferred material for the coiled tubing because of its superior springiness and memory, however, any suitable material may be used. The coiled portion allows the cables and hoses to be stretched and elongated, which greatly increases the floor area where the given OR equipment may be located, increasing the flexibility of the OR layout. The stretchable tubing also decreases the number of ceiling connection locations that are necessary to provide connection options for the whole OR.

In some examples, a "tail" portion (e.g., like **78** in FIG. **12**) of relatively straight, relatively flexible cord, cable, tubing or hose is attached to the distal end of the coiled tubing hanging near the ceiling. In some examples, the transition between the coiled portion and the tail portion does not require the connection of two dissimilar materials. In some examples, the coiled tubing may be simply be straightened in a heating process that relaxes the memory of the coil. In this case the coiled portion and the tail portion are the proximal and distal ends of the same piece of tubing. In some examples, the tail portion hangs down to a level that can be reasonably reached by a person standing on the floor, and yet not hang down far enough to hit OR personnel in the head when not attached to equipment. In some examples, the distal end of the tail portion terminates approximately 7 feet above the floor. The coiled portion allows the stretched cables and hoses to recoil when not hooked to equipment, thus naturally lifting the distal connectors up to a level that can protect OR personnel from being hit in the head. The relatively straight tail portion reduces visual clutter hanging from the ceiling and reduces the chances of adjacent cables and hoses tangling when connected to a given piece of equipment.

In some examples, the coiled cords, cables, tubing or hoses may be attached near the distal end of a light-weight arm that can rotate around an axis near its proximal end. The proximal end of the arm can be attached to the ceiling at the axis. The supply lines for the cords, cables, tubing or hoses emerge from the ceiling near the axis and then run toward the distal end of the arm where they hook to the coiled cords, cables, tubing or hoses that can be pulled down and attached to the module **10**. The rotation of the arm around its axis creates an arc that covers a large area of the ceiling and allows significant flexibility in where the coiled cords, cables, tubing or hoses may conveniently hang down to be attached to the module **10** or other surgical equipment.

Waste air is currently discharged from every piece of electrical and electromechanical surgical and anesthesia equipment in the operating room. The discharged air is simply blown into the operating room, usually near the floor where the given piece of equipment is located. Waste heat and air discharged near the floor has been shown to form into rising convection currents of heated air that can carry infectious contaminates from the floor up and into the sterile surgical field. Waste heat vented near the floor is a dangerous surgical infection risk. Contaminated waste air blowing from heater-cooler units has been genetically linked to heart valve infections.

The problem is that all electronic and electromechanical equipment produce waste heat that must be dissipated, or the equipment can be damaged. Typically, this is accomplished with a cooling fan that simply discharges the waste heat and waste air into the operating room. Additionally, some pieces of surgical and anesthesia equipment such as forced-air warming, produce heated air on purpose and then it becomes heated waste air. The waste air and heat from forced-air warming can cause contamination of the sterile surgical field and cause implant infections. Discharging waste heated air into the operating room, especially close to the surgical table and sterile field, is dangerous because it causes contamination of the sterile filed which has been linked to implant infections, especially joint implant infections. Therefore, this waste air and heat should be vacuumed, processed and safely discharged in order to prevent sterile surgical field contamination and catastrophic implant infections.

In other examples, the vacuumed air from the surgical field such as surgical smoke evacuation or ventilation dead-zone evacuation or waste oxygen and alcohol evacuation, must also be processed and safely discharged.

In some examples, and as shown in illustrative module **1610** of FIGS. **16** and **17**, the modules **1610** and **1710** can include a waste air management system **84**. The waste air management system **84** may include an inlet vent **86** with a connector **88** that can connect to one or more vacuum hoses **90** (FIG. **20**, **22**) designed to vacuum waste air from a specific location. In some examples, where more than one inlet vent **86** is provided (e.g., **86**, **86**B-**86**H, it may be advantageous to have the various air and vacuum hoses **90** connected (e.g., operably couplable) to the waste air management system **84** by way of "keyed" connections **88** (FIG. **20**, **22**) so that they are not mistakenly attached to the wrong inlet **86**, **86**B-**86**H. For example, the hose connection **88** may be any other shape than the traditional round shape, for example: triangular, square, five or six sided, oval, diamond shaped or any other shape. In some examples, the inlet vents **86**, **86**B-**86**H on the waste air management system **84** and the connectors **88** on the specific vacuum hose **90** may be color coded for easy identification.

In some examples, the waste air management system **84** includes an air plenum **92** containing an air filter **94**. The filter **94** may advantageously be a HEPA (99.97% efficient) or "near HEPA" filter. The one or more air inlet vents **86**, **86**B-**86**H can allow waste air to enter the plenum **92** from either the equipment housed in the module **1610** or from external equipment sources. As previously described, a flapper door could be provided at the inlet vents **86** into the housing or into the plenum in order to keep the inlet vents **86** closed unless being used. In some examples, a low filtration efficiency pre-filter may be placed near the inlet vents **86** in order to prevent organic contaminates such as airborne body fluids, bone or tissue fragments, from entering and contaminating the interior of the waste air management system **84**.

In some examples, plenum **92** may contain a particle ionizer that may be located in the airflow path before the filter **94**. The particle ionizer adds electrical charges to the suspended particles in the airflow path, causing them to stick together and become larger. Larger particles are easier to capture in the filter **94** and thus the filtration efficiency of the entire waste air management system **84** is improved. In many cases, adding electrical charges to bacteria also results in killing the bacteria.

In some examples, inlet vents **86** may be purposefully located near the floor or even facing the floor and located under the module **10**. When the waste air management system **84** has excess capacity compared to the amount of air being vacuumed from the surgical field and needed for equipment cooling, inlet vents **86** located near the floor may be opened to allow the intake of contaminated air from near the floor. For example, when the vacuum created by the fan **96** is greater than a specified amount, inlet vents near the floor automatically open up (either electronically or mechanically) to evacuate contaminated air from under the table so that when the surgeon is standing next to the table and moves around, the surgeon doesn't stir up particles.

The contaminated air from near the floor can then be filtered by the waste air management system **84** and discharged as clean air back into the operating room. In so doing, the waste air management system **84** uses its excess air cleaning capacity to decrease the total number of airborne contaminating particles in the OR and thus reducing the risk of surgical implant infections. This is particularly advantageous because it is uniquely vacuuming and filtering the contaminated air from near the floor adjacent the surgical table that has the highest probability of reaching the sterile surgical field.

In some examples, a fan **96** (e.g., any suitable blower) can propel waste air received via inlet vents **86** through the filter **94** and exhaust the waste air from the plenum **92** into a substantially vertical vent tube **98**. In some examples, the substantially vertical vent tube **98** extends upward to a height of more than 5 feet above the floor, before discharging the processed waste air from outlet vents **100** near the top of the substantially vertical vent tube **98**. In some examples, a sock-like filter may be added to the outlet vent **100** in order to diffuse the outlet air and muffle any fan noise. In some examples, the vertical vent tube can be any shaped channel configured to guide the flow of air. In some examples the vertical vent tube includes directing air more vertically than horizontally with respect to a ground the module is configured to be paced on. In some examples, the vertical vent tube can be linear, angled, bent or curved portions or can be solely linear, angled, bent or curved, such that discharging the waste air upward is achieved.

In some examples, the inlet vent **86** is attached to an air plenum **92** located in the module **1610**. The air plenum **92** can be designed to direct inlet air through a filter **94** and fan **96** before safely discharging it into the operating room. In some examples, the filter **94** is located in the airflow path before the fan **96** so that the air contacting the fan **96** has already been cleaned by the filter **94**. Contaminated air has been shown to contaminate fans, which are very difficult to clean and may aerosolize contaminates into the discharged air. In some examples, the fan **96** may be located between the air inlet vent **86** and the filter **94**. In some examples, all of the ducting and plenums of the waste air management system **84**, are accessible on their internal surfaces for cleaning and decontamination.

In some examples, the filtered waste air is then directed through ducting **102** which functions as a substantially vertical vent tube **98**, up the tower-like upper section **20**, to be vented **100** out near the top of the tower-like upper section **20**. In some examples, the filtered waste air is then directed through the cowling **12** of the tower-like upper section **20** which functions as a substantially vertical vent tube **98**, to be vented out **100** near the top of the tower-like upper section **20**. In some examples, a sock-like filter may be added to the outlet vent **100** in order to diffuse the outlet air and muffle any fan noise.

In some examples, the substantially vertical vent tube **98** may be a rigid tube. In some examples, the substantially vertical vent tube **98** may be the tower-like upper section **20** of the module (e.g., **1610** and **1710**).

In some examples, and as shown in illustrative modules **1810** and **1910** of FIGS. **18** and **19**, the substantially vertical vent tube **98** can be an inflatable, collapsible tube **104** made of fabric, plastic film or fabric laminated to or coated with a plastic film. In some examples, the inflatable, collapsible tube **104** may be disposable. In some examples, the distal end **106** of the inflatable, collapsible tube **104** is made of woven or non-woven fabric that serves both as a flow obstruction to increase the pressure in the tube and also as a final filter before the waste air is discharged.

In some examples, and as shown in FIGS. **18** and **19**, the inflatable, collapsible tube **104** includes a substantially sealed distal end **106** with one or more holes in the walls of the tube to allow the air to escape but create a flow obstruction causing the pressure within the inflatable, collapsible tube **104** to increase. The increased pressure in the inflatable tube **104** causes the inflatable tube **104** to assume an erect shape. In some examples as shown in FIG. **18**, the erect inflatable, collapsible tube **104** extends substantially vertically in order to terminate at a height of more than 5 feet above the floor. In some examples as shown in FIG. **19**, the erect inflatable tube **104** extends diagonally at an upward angle. Depending on the direction of the angled portion, the distal top end **106** of the inflatable tube **104** may be positioned outside of the operating room ventilation flow field for added safety.

In some examples, the waste air management system **84** produces a relatively high-volume airflow (10-100 CFM) at relatively low positive and negative (vacuum) pressures (less than 2 inches of water). This allows the fan **96** in the lower section **14** to operate at relatively slow speeds under normal conditions in order to minimize the fan noise. The large volume of the bulbous lower section **16** of the module **10** advantageously allows the fan **96** of the waste air management system **84** to be relatively large in diameter. Large diameter fans may produce high volume airflows with relatively slow fans speeds. In some examples, the waste air management system **84** includes noise cancelation or active noise control electronics (e.g., noise canceling device **210**. Noise cancelation technologies work by generating a sound waves that are in an inverted phase or antiphase to the sound waves of the noise to be cancelled. When the antiphase waves are superimposed on each other, they cancel each other out through destructive interference. Noise cancellation is particularly effective in cancelling repetitious sounds such as fan noise. The noise-canceling device **210** may be located in the module **10** or within the air-flow pathway or both (FIG. **4**).

In some examples, the waste air management system **84** may safely process the waste air that is the by-product of equipment contained within the module **10**. In some examples, inlet vents **86** into the plenum **92** are in fluid connection with the interior space of module **10**. Waste heated air that has cooled the equipment in the module **10**, may be vacuumed from the equipment space into the plenum **92** for safe processing and discharge.

In some examples, the waste air management system **84** may safely process the waste air that is the by-product of other surgical and anesthesia equipment. Waste air producing surgical equipment includes Heater-cooler units (HCU) that produce contaminated waste heated air that needs to be processed and safely discharged. In this case, the waste heated air is a by-product of cooling the refrigeration compressor of the HCU that has been contaminated by water leaking from the water chiller. Forced-air warming units (FAW) also produce contaminated waste heated air that needs to be processed and safely discharged. The FAW systems exhaust waste air from under the surgical drape where it may escape from under the surgical table near the floor. In some examples, this waste heated air from FAW can be contained and vacuumed up for safe disposal. Electrosurgical units and other surgical equipment also produce waste heated air that needs to be processed and safely discharged. Conventionally, these various pieces of equipment in the operating room are not stored proximate one another in a module **10** (e.g., module including a cowl or seal) with a common waste air management system **84**. Anesthesia monitoring is generally located in the non-sterile anesthesia field, while the surgical focused equipment is located distal from the anesthesia monitors.

In some examples, a vacuum hose **90** may terminate near or in the waste heat and waste air producing equipment. In some examples, it may be advantageous to attach a collection "funnel" to the end of the vacuum hose in order to direct the waste air into the hose end. In some examples as shown in illustrative module **2010** of FIG. **20**, the funnel **122** may be a rigid construction if it is gathering air from the outlet vent of a specific piece of equipment such as a heater-cooler unit. In some examples, the funnel **122** may be a flexible construction, for example a sheet of plastic film, if it is gathering air from the discharge area of a forced-air warming blanket. In some examples, the perimeter of the sheet of plastic film may be adhesively bonded to the open end of the underside of a FAW blanket.

In some examples, the vacuum hose **90** for the evacuation of waste air from surgical and anesthesia equipment may be lightweight, thin walled, inexpensive hose, ½-2 inches in diameter. The vacuum hose **90** may advantageously be made of polyethylene, polypropylene, PVC or other plastic materials. The vacuum hose **90** may advantageously be corrugated. In some examples, the proximal end of the vacuum hose **90** for the evacuation of waste air from surgical and anesthesia equipment is a uniquely shaped connector **88** such as square or triangular for example.

In some examples, the waste air management system **84** may safely process the waste air and smoke that is the by-product of the electro-cautery used for tissue cutting and coagulation. This smoke has been shown to be a hazard to the surgical staff because it may contain carcinogens and may contain viruses.

As shown in FIGS. **21**A, in some examples, a smoke evacuation suction system used for evacuating electrosurgical smoke may include a hose **90** hooked to a vacuum source. The distal end of the hose **90** may be located near the surgical wound that is being cauterized or tissue being cut with electro-cautery. The distal end of the hose **90** may be attached to the active electrode of the electro-cautery or it may be located near the surgical wound. If it is located near the surgical wound, the distal end **116** of the hose **90** may be secured to the sterile surgical drape with an adhesive element **130**A, **130**B. Any other suitable securing method, such as, but not limited, to clips and ties may also be provided.

In some examples, the proximal end connector **88** (e.g., FIG. **22** of the smoke evacuation hose **90** for smoke evacuation from the surgical field, may be attached to the inlet vent **86** of the waste air management system **84**. The smoke from the electro-cautery may be safely vacuumed from the surgical field and then filtered in the waste air management system **84**. In some examples, the hose **90** for smoke evacuation may be lightweight, thin walled, inexpensive hose, ⅜-¾ inches in diameter. The tubing may advantageously be made of polyethylene, polypropylene, PVC or other plastic materials. The hose **90** may advantageously be corrugated. In some examples, the proximal end connector **88** of the smoke evacuation hose **90** is a uniquely shaped connector **88** such as square or triangular for example.

In some examples, the waste air management system **84** may safely process the waste air that is the by-product of the operating room ventilation optimization system. It has been shown that flow-boundary dead zones naturally form around the surgeons and in front of anesthesia screen. This is a natural phenomenon that occurs anytime a fluid (or gas) flows next to a non-moving object—a boundary layer of non-moving fluid (or gas) is formed as shown in FIG. **21**A. These flow-boundary "dead zones" **110** that form around the surgeons **108** and staff, effectively prevent the downward ventilation airflow **112** from the ceiling of the operating room from reaching the open surgical wound **114**. When the ventilation airflow **112** stops, contaminating particles and bacteria that had been kept airborne by the moving air, are allowed to settle into the wound **114**. When the ventilation airflow **112** slows or even stops due to dead zone **110** interference, gravity takes over and the airborne contaminates settle into the wound **114** where they may cause infections.

In some examples, and as shown in FIG. **21**B, we have shown that the negative effects of these dead zones **110** can be minimized by vacuuming out the dead zone air, which allows the ventilation air **112** to flow past the wound **114**, keeping airborne contaminating particles and bacteria, airborne in the moving air where they do no harm.

In some examples, and as shown in FIG. **21**B, a ventilation optimization system includes ventilation dead zone **110** evacuation; by vacuuming the air from the flow-boundary dead zones **110** that naturally form in front of the surgeons **108** and anesthesia screen **30**, the interference of the flow-boundary layers with the operating room ventilation **112** is reduced. This allows the ventilation airflow **112** from the ceiling to reach the wound **114** unimpeded by a flow-boundary dead zone **110**. These interfering dead zones **110** of non-moving air can be evacuated by placing a distal end **116**, **116**A-C (e.g., distal end portion) of vacuum hose(s) **90** into the dead zone **110** to suck out or literally deflate the deadzone. The evacuated air can then be processed in order to safely discharge the air, back into the operating room. In some examples, the distal end **116** of the vacuum hose **90** (e.g., dead zone evacuation hose) may be secured to the sterile surgical drape, such as near or in front of the surgeon **108** (e.g., surgeon position), with an adhesive element. Any other suitable securing method, such as, but not limited, to clips and ties may also be provided.

In some examples, the distal end **116** of the vacuum hose **90** may include a single large hole between the inside and the outside of the vacuum hose **90**. The single large hole may be substantially the same diameter as the vacuum hose **90**. The large hole allows unimpeded airflow while producing minimal airflow noise. In some examples, there are multiple relatively large holes (>0.25 in. diameter) near the distal end **116** of the vacuum hose **90**. In some examples, there are multiple smaller holes (<0.25 in. diameter) near the distal end **116** of the dead zone evacuation hose **90**, essentially creating a screen-like air inlet to vacuum hose **90**. The number of holes and the size of the holes is determined so as to allow an air flow of between 5 and 50 CFM.

In some examples, the distal end **116** of the vacuum hose **90** may be used to evacuate surgical smoke. Traditionally, surgical smoke is evacuated by an air hose attached directly to the end of the electrosurgical active electrode or "pencil." Surgeons find this added hose to be cumbersome. The distal end **116** of the vacuum hose **90** may be located adjacent the surgical wound **114** and can evacuate the surgical smoke from above the surgical wound **114** being carried in the ventilation airflow **112**, as it flows past the distal end **116**. In this case, a cumbersome hose attached directly to the end of the electrosurgical "pencil" may be unnecessary. By evacuating the dead zone **110** with the vacuum hose **90**, the ventilation airflow **112** containing the surgical smoke is naturally directed from over the wound **114**, laterally toward the distal end **116** of the vacuum hose **90** adjacent the surgeon **108**.

In some examples, the distal end **116** of the vacuum hose may be placed in other flow boundary layer or ventilation dead zone areas such as those that form next to the anesthesia screen **30**, under the surgical lights or under a Mayo stand. Similar to the ventilation flow dead zones that form in front of the surgeons, these other dead zones can be evacuated in order to allow the ventilation airflow **112** to flow unimpeded and thus keep the contaminating airborne particles airborne.

Features of the vacuum hose **90** and distal end **116**, **116**A-C can also be used to collect air from areas of the surgical field that are not considered dead zones, but that may benefit from air collection and filtering. Some of these areas can include areas of turbulent or non-laminar airflow. Air collection using vacuum hose **90** may also be performed in areas of generally laminar airflow.

In some examples, the proximal end of the dead zone evacuation hose **90** exiting from the surgical field may be attached to the inlet vent **86** of the waste air management system **84** (FIGS. **16**, **17**). The waste air from the dead zone evacuation may be safely filtered in the waste air management system **84**. In some examples, the hose **90** for dead zone evacuation may be lightweight, thin walled, inexpensive hose, ½-2 inches in diameter. The hose **90** may advantageously be made of polyethylene, polypropylene, PVC or other plastic materials. The hose **90** may advantageously be corrugated. In some examples, the proximal end of the dead zone evacuation hose **90** is a uniquely shaped connector **88** such as square or triangular for example (FIGS. **20**, **22**).

In some examples, the waste air management system **84** may be used to evacuate or dilute the air under the surgical drape (e.g., **32** in FIG. **4**), especially near the patient's head, neck and chest (e.g., near **24** in FIG. **4**). Alcohol from the surgical prep solution may pool under the surgical drapes **32** and then evaporate. Waste oxygen from an unrestricted oxygen supplementation system such as nasal prongs or facemask may allow waste oxygen to pool under the surgical drape, especially near the patient's head, neck and chest. When a spark from either the electro-cautery or a laser is added, highly dangerous operating room fires can occur. Even the surgical drape can burn in the presence of an oxygen-enriched environment. It may be advantageous to remove the air and oxygen and alcohol vapors trapped under the surgical drape.

In some examples, and as shown in FIG. **22**, a vacuum hose **90** may be placed near the shoulders, chest and neck of the patient. Vacuum hose **90** may include any of the features described with reference to vacuum hose **90** described with respect to FIGS. **20**, **21**A and **21**B. The distal end **116'** of the oxygen/alcohol vacuum hose **90** may terminate in a single hole, multiple holes or even multiple smaller hose "tentacles" **126**A', **126**B', each with one or more holes **128**A' and/or **128**B' and each located near the patient. In some examples, longer "tentacle" oxygen/alcohol vacuum hoses **126**A', **126**B' may extend over the patient's chest or along their sides to terminate with the holes **128**A', **128**B' near the abdomen. In some examples, the distal end of the "tentacle" hoses **126**A', **126**B' may be secured to the patient with one or more adhesive patches **130**A' and/or **130**B'. The adhesive patches can include any suitable coupling element, and can alternately be couplable to the anesthesia screen, surgical drape, etc.

In some examples, the proximal end of the vacuum hose **90** for evacuating oxygen/alcohol exiting from the surgical field may be attached to the inlet vent **86** of the waste air management system **84**. The waste air from the oxygen/alcohol evacuation vacuum hose **90** may be safely filtered in the waste air management system **84**. In some examples, the vacuum hose **90** for oxygen/alcohol evacuation may be lightweight, thin walled, inexpensive hose, ⅜-1 inch in diameter. The vacuum hose **90** may advantageously be made of polyethylene, polypropylene, PVC or other plastic materials. The vacuum hose **90** may advantageously be corrugated. In some examples, the proximal end of the oxygen/alcohol evacuation vacuum hose **90** is a uniquely shaped connector **88** such as square or triangular for example.

In some examples, the waste heated air can be vacuumed by the waste air management system **84**, filtered and discharged at a height that does not allow any waste heat to mobilize contaminates normally resident near the floor, up and into the sterile field. In other words, the air discharged from the waste air management system **84** may advantageously be at a height that is greater than 4 feet off of the floor. However, in some examples, at least a portion of the air discharged from the waste air management system **84** may be diverted and used as a source of positive pressure air.

For example, the waste air management system **84** may be used to dilute the air under the surgical drape (e.g., **30**, FIG. **4**), especially near the patient's head, neck and chest. Alcohol from the surgical prep solution may pool under the drapes and then evaporate. Waste oxygen from an unrestricted oxygen supplementation system such as nasal prongs or facemask may allow waste oxygen to pool under the surgical drape, especially near the patient's head, neck and chest. When a spark from either the electro-cautery or a laser is added, highly dangerous operating room fires can occur. Therefore, in contrast to vacuuming waste air and oxygen, it may be advantageous to dilute the air and oxygen and alcohol vapors trapped under the surgical drape by blowing fresh air into the space under the drapes. In some examples, this air can be provided by the air discharged from the waste air management system **84**.

In some examples, and again with reference to FIG. **22**, the air hose **116'** may be configured to be placed near the shoulders, chest and neck of the patient. The distal end of the oxygen/alcohol evacuation/dilution air hose **116'** may terminate in a single hole, multiple holes or even multiple smaller hose "tentacles" **126**A', **126**B', each with one or more holes **128**A', **128**B' and each located near the patient. In some examples, longer "tentacle" oxygen/alcohol dilution air hoses **126**A', **126**B' may extend over the patient's chest or along their sides to terminate with the holes near the abdomen. In some examples, the distal end of the "tentacle" air hoses **126**A' may be secured to the patient, a table or a surgical drape with an adhesive patch **130**A' and/or **130**B'.

In some examples, the proximal end of the oxygen/alcohol dilution air hose exiting from the surgical table may be attached to the outlet connector **118** of the waste air management system **84**. The outlet connector **118** may attach to the discharge side of the waste air management system **84** in order to utilize the positive pressure air being discharged from the system **84**. In some examples, the air hose **116'** for oxygen/alcohol dilution air may be lightweight, thin walled, inexpensive hose, ⅜-¾ inch in diameter. The air hose **116** may advantageously be made of polyethylene, polypropylene, PVC or other plastic materials. The air hose **116** may advantageously be corrugated. In some examples, the proximal end of the oxygen/alcohol dilution air hose **116** is a uniquely shaped connector **88** such as square or triangular for example.

In some examples, the output of the waste air management system **84** may be diverted into an air hose (e.g., **116**) that may be hooked to an inflatable "hover" mattress for moving the patient off of the surgical table at the end of surgery. The fan **96** in the waste air management system **84** conveniently provides the pressurized air for a "hover" mattress. Air may be diverted from the outlet side of the waste air management system **84**, into an air hose **116** that is attached to a "hover" mattress. Since the "hover" mattress requires higher air pressure and higher airflow than the low velocity low pressure airflow normally produced by the waste air management system, the fan **96** of the waste air management system **84** may advantageously have two or more speeds. When the "hover" mattress is in use, the fan **96** of the waste air management system **84** may be speeded up to a higher RPM, thus delivering higher air pressures and air volumes, accepting a brief period of more fan noise. In contrast, under normal conditions when the "hover" mattress is not inflated, the fan **96** may be operated at a slower speed to reduce the annoying fan noise.

In some examples, when the output of the waste air management system **84** is diverted into an air hose (e.g., **116**) that is hooked to an inflatable "hover" mattress, the diversion valve may automatically close the normal exhaust ducting **102**. Therefore, the air pressure in the diversion air hose **116** may be substantially increased, as required to inflate the inflatable "hover" mattress.

As shown in the illustrative module **2810** of FIG. **28**, in some examples, one or more fluid suction canisters **154** for waste fluid and blood may be conveniently mounted on the module **2810**. A vacuum hose **300** from the OR ceiling to, for example, the top of the tower of the module **2810** can eliminate the need for that hose to traverse the floor from a wall outlet. Mounting the fluid suction canisters **154** on the module **2810** also allows the suction hose **160** from the surgical field to reach the fluid suction canister **156** without touching the floor.

In some examples as shown in FIG. **28**, the one or more fluid suction canisters **154** may be accommodated in bucket-like recesses **156** formed in or coupled to the module **2810**, on the side facing away from the patient **48** or the rear side **50** of the module **2810**. In the case of multiple canisters, the suction hose **160** from the surgical field may be split into two or more "tail" hoses that can each be hooked to the top of a collection canister **154** (e.g., fluid suction canister, waste fluid storage device). In some examples, two or more vacuum hoses **162** may emerge from the module **2810** cowling **12** to be attached to the top of the fluid suction canisters **154**. In some examples, the two or more vacuum hoses **162** can include one or more flow valves **161**. In some examples, each vacuum hose **162** can have a flow valve **161**, to control which fluid suction canister **154** is receiving the vacuum at any given time. The one or more flow valves **161** can include any suitable flow managing device.

In some examples as shown in FIG. **29**, the one or more fluid suction canisters **154** may include a disposable fluid suction bag **158** that serves as an inner liner for fluid suction canister **154**, or can replace fluid suction canister **154**. The disposable fluid suction bag **158** prevents the more robust and expensive fluid suction canister **154** from being contaminated by blood and bodily fluids. In this case, the vacuum hose **162** from the module **2810** and the suction hose **160** from the surgical field both enter the top of the disposable fluid suction bag **158**. In some examples, the top of the disposable fluid suction bag **158** can include a molded plastic cover **164** with a diameter that is larger than the upper diameter of the fluid suction bag **158**. The outer rim of the molded plastic cover **164** is designed to create an airtight seal with the upper edge of the fluid suction canister **154**. When the molded plastic cover **164** is sealed to the upper edge of the fluid suction canister **154**, a vacuum **198** can be introduced into the space between the fluid suction bag **158** and the fluid suction canister **154**. The negative pressure vacuum **198** in the space between the fluid suction bag **158** and the fluid suction canister **154** may be more negative than the negative pressure vacuum inside the fluid suction bag **158**, in order to maintain the fluid suction bag **158** in a fully expanded condition.

In some examples, the negative pressure vacuum **198** in the space between the fluid suction bag **158** and the fluid suction canister **154** can be induced by one or more vacuum pumps in the module **2810**. Advantageously, these vacuum pumps can be capable of creating a more negative air pressure than the hospital vacuum system that is applied to the inside of the fluid suction bag **158**.

In some examples, the fluid suction bag **158** can be made of plastic film. In some examples, the fluid suction bag **158** can be made of blow-molded plastic. Other plastic bag construction techniques are anticipated. In some examples, the fluid suction bag **158** is made of inexpensive polyethylene or polypropylene plastic materials.

In some examples, one or more fluid level sensors **153**, such as, but not limited to, optical or infrared sensors, may be conveniently mounted in the wall of the bucket-like recesses **156** in the module **10**, adjacent the fluid suction canister(s) **154**. Optical and infrared sensors rely on the relative increased absorption of transmitted light by blood and fluid compared to air in order to determine a fluid level. In some examples, the fluid level monitors may automatically activate or deactivate the vacuum valves to a given canister, thereby automatically shifting the blood and fluid flow to a new canister as the previous one is filled. In some examples, the surgical nurse can be wirelessly notified on their portable monitor, that one or more canisters are full of blood and fluid and may need to be replaced before the surgical procedure is finished.

Blood and fluid sucked from the surgical sight frequently contains many air bubbles and foam that falsely expand the blood and fluid volume and may cause the canister to overflow, if volume were to be measured by weight for example. In some examples, optical or infrared fluid level sensors **153** may be advantageous compared to other fluid level sensors because they respond to an absolute volume of fluid (including air bubbles and foam) in the fluid suction bag **158** or the fluid suction canister **154**. In some examples, optical or infrared fluid level sensors **153** ideally serve as a shutoff sensor, preventing the overflow of blood and fluids into the hospital vacuum system.

In some examples, optical or infrared fluid level sensors **153** may not be ideal for determining an accurate blood and fluid volume in the fluid suction bag **158** or the fluid suction canister **154**. An accurate blood and fluid volume needs to subtract the volume added by air bubbles and foam. In some examples, weight is the most accurate determination of the blood and fluid volume in the fluid suction bag **158** or the fluid suction canister **154**, because it excludes the confounding influence of air bubbles. By subtracting the dry weight of the fluid suction bag **158** and/or the fluid suction canister **154** from the measured weight of the canister containing blood and fluid, the volume of blood and fluid can easily and accurately be determined, irrespective of the volume of air bubbles and foam in the blood and fluid.

In some examples, an electronic scale **155** is positioned to weigh the fluid suction canister **154**. Measuring the weight of the blood and fluid is far more accurate than the traditional method of visually measuring or "guesstimating" the volume of blood and fluid in a fluid suction bag **158** or the fluid suction canister **154**. Since blood and fluid has virtually the same specific gravity as water, each 1 gram of blood and fluid weight equates to 1 ml of blood and fluid volume. The volume of the air bubbles and foam are automatically excluded.

In some examples, the fluid suction bag **158** and/or the fluid suction canister **154** can be attached to an electronic scale **155** for measuring the weight of the fluid suction bag **158** and/or the fluid suction canister **154** plus the blood and fluid in the bag or canister. In some examples, the electronic output of the electronic scale **155** that can be attached to the fluid suction canister **154** is directly reported on a patient monitor display **38**A, **38**B. In some examples, the electronic output of the electronic scale **155** that is attached to the fluid suction canister **154** is digitized and reported (e.g., generated and a signal sent) to a processor (such as processing circuitry **157**) that is programed to record the beginning weight (e.g., establish a zero point) of the fluid suction bag **158** and/or the fluid suction canister **154** and together (operably coupled) with a controller **165***a* of a control module **165***b*, automatically subtract that beginning weight from subsequent recorded fluid suction canister **154** weights, to determine the blood and fluid loss during surgery. In some examples, the total blood and fluid loss and in some cases blood and fluid loss per hour determined (e.g., calculated) by the processor, are then reported (e.g., displayed) on a patient monitor display **38**A, **38**B. In some examples, the total blood and fluid loss and in some cases blood and fluid loss per hour determined by the processor, may be automatically recorded in the electronic anesthetic record (e.g., a memory, machine readable medium). Other time values besides fluid loss per hour can be used, such as fluid loss per minute, fluid loss per second, etc.

In some examples, it may be desirable to determine the blood loss during surgery rather than total blood and fluid loss, since some or even most of the "fluid" is irrigation fluid introduced by the surgeon. The blood loss can be determined by comparing information about a concentration of a blood characteristic in the waste fluid. Blood characteristics that can be used include, but are not limited to, hematocrit concentration and hemoglobin concentration. For example, blood loss can be calculated if the hematocrit (Hct) or hemoglobin concentration (Hgb) of the patient, the hematocrit (Hct) or hemoglobin concentration (Hgb) of the fluid in the suction canister **154** and the volume of the blood and fluid in the suction canister **154** (excluding air bubbles and foam) are known. The formula is: Blood loss=$Hct_{canister}$/$Hct_{patient}$×fluid $vol_{canister}$. Accurate measurement of the fluid volume of the canister by weight has been discussed. The Hct of the patient can be directly measured by infrared spectroscopy or by recent lab results. The Hct of the canister can be measured or approximated by a variety of techniques including but not limited to: infrared spectroscopy, centrifugation, visible light photo absorption and microfluidic cell counting. In some examples, the total blood and in some cases blood loss per hour determined by the processor, may be automatically recorded in the electronic anesthetic record. In some examples, the processor may include an algorithm for more accurately determining the need for a blood transfusion. For example, the processor can determine if a measured blood loss value has traversed a blood loss threshold.

In some examples, it may be desirable to agitate and mix the contents of the fluid suction bag **158** or the fluid suction canister **154** in order to assure a more accurate determination of the Hct of the blood and fluid in the canister. In some examples, it may be desirable include a magnetic stirrer in the fluid suction bag **158** or the fluid suction canister **154**. A small bar magnet **159** with N and S poles is placed in the bottom of the fluid suction bag **158** or the fluid suction canister **154**. A corresponding bar magnet is mounted on a spinning shaft and positioned to spin horizontally just below the bucket-like recesses **156** in the module **10**. The opposite poles of each magnet are attracted to each other causing the magnet **159** in the canister to spin in unison with the magnet below the bucket-like recesses **156**, mixing the blood and fluid in the canister. In some embodiments the bar magnet **159** in the canister may be coated in plastic. In some embodiments the plastic coating may be molded to include a substantially sphere-shaped bump located near the mid-point of the magnet **159**. The bump may provide an axis of rotation for the magnet **159** to more easily spin in the blood and fluid.

In some examples, it may be desirable to agitate and mix the contents of the fluid suction bag **158** or the fluid suction canister **154** in order to assure a more accurate determination of the Hct of the blood and fluid in the canister. In some examples, it may be desirable include a bubbler in the fluid suction bag **158** or the fluid suction canister **154**. In some embodiments, the proximal end of a small tube **163** may be hooked to an air source within the module **10** and terminate with its open distal end near the bottom of the fluid suction bag **158** or the fluid suction canister **154**. Small air bubbles pumped into the blood and fluid in the canister agitate and mix the contents as they rise to the surface. The bubbles also assure that the blood in the canister is fully oxygenated, making the quantification with infrared spectroscopy or visible light photo absorption easier and more accurate, in some cases only requiring a single wavelength of light. In some embodiments the small tube **163** may also serve as a sampling tube for withdrawing a small amount of the contents of the fluid suction canister **154** or fluid suction bag **158**, for analysis of the hematocrit.

In some examples, a suction hose from the anesthesia suction device may be attached to fluid suction bag **158** or the fluid suction canister **154**, in order to eliminate the need for additional suction canisters. This combination is possible because the fluid suction bags **158** or the fluid suction canisters **154** are mounted on the module **2810**, adjacent the patient.

In some examples, module **3010** can include a disinfecting (e.g., sanitizing) system. For example, Ultraviolet light (UV), especially UV light in the "C" portion of the spectrum can kill nearly all types of microorganisms. In some examples, UV-C includes lights emitting wavelengths in the 200 nm to 280 nm range. Some germicidal lights may go as high as wavelengths of 300 nm. In recent years UV-C has steadily gained acceptance as an effective technique for disinfection in the OR. The challenges with UV-C disinfection include: adequate UV power or intensity ("field strength"), adequate duration of exposure, expense, adequate "sight lines" to assure that the upper surfaces of the equipment in the OR (especially the surfaces contacting the patient, the staff and the supplies) are radiated and adequate protection of the relatively delicate UV-C bulbs when not in use.

In some examples, and as shown in FIGS. **30** and **31**, the module **3010** may be used as a storage and mounting platform for a disinfecting system **165**, such as a sanitizing system including UV-C lights **166**. Other suitable disinfecting systems may also be mounted to module **3010**, including but not limited to, a spray disinfecting system or an ozone disinfecting system. In some examples, a cartridge **168** for mounting multiple UV-C lights **166** (which may look like fluorescent light tubes) may be safely housed in the tower-like upper section **20** of module **10**.

In some examples as shown in FIGS. **30** and **31**, the UV-C cartridge **168** may be elevated from its storage location within the upper section **20** of module **3010**, emerging from the top of module **3010**. (However, in some examples the cartridge **168** may remain on top of the module **3010** and not emerge or be retracted into the module **3010**).

In some examples, the UV-C cartridge **168** may advantageously be located 5-9 feet in the air when it is located on the top of module **10**. From this relatively high location in the OR, the UV-C lights **166** can advantageously shine outward and/or downward onto the upper surfaces of the equipment in the room; the surfaces contacting the patient, the staff and the supplies.

In some examples, the UV-C cartridge **168** may be elevated above the module **3010** by an air cylinder actuator **202** or other electro-mechanical mechanism for UV-C exposure and then safely stored within the upper section **20** between exposures. In other words, when in use, the sanitizing system **165** at least a portion of the system **165** can be extended out of the module **3010**, and when not in use, at least a portion of the sanitizing system **165** can be retracted into the module **3010** and stored in the module **10**.

In some examples as shown in FIG. **31**, the UV-C cartridge **168** may include UV-C lights that extend outward **170** creating "sight lines" **204** that can radiate and disinfect module **3010**. The UV-C lights that extend outward **170** may be housed in module **3010** as part of the UV-C cartridge **168** and then automatically deploy outward when the UV-C cartridge **168** is elevated. The UV-C lights shining on the module **3010** advantageously disinfect the module **3010** automatically.

In some examples, as shown in FIGS. **30** and **31**, the UV-C lights **172** may be mounted on module **3010** near the floor. UV-C lights near the floor **172**, advantageously have "sight lines" **206** to the undersurfaces of equipment and the floor of the OR. The combination of the UV-C lights **166** shining downward and the UV-C lights **172** near the floor shining upward, outward and/or downward, creates the maximum probability of having a clear "sight line" **204**, **206** to an organism in any location.

In some examples, the UV-C disinfection system may be controlled by a timer. At a designated time when the OR is not in use, 3 AM for example, the UV-C cartridge **168** may be automatically elevated above the module **3010** by the air cylinder actuator or other electro-mechanical mechanism **202**, for UV-C exposure. Then after a prescribed exposure time, the actuator **202** may automatically retract the UV-C cartridge **168** back into the upper section **20** for safe storage. Since each OR would presumably have its own module **3010**, each room can be automatically and economically disinfected with UV-C light, one or more times each day. The disinfection system can include one or more motion sensors **208** to detect motion. For example, if a person is in the room or in a location where they could be exposed to the UV light, based on the detection of motion, the disinfection system can be altered, or the output reduced. In some examples, detection of motion can include the processor (e.g., **157**) determining that the disinfection system should be interrupted and sending an instruction to the actuator **202** to retract the disinfection system or to the controller to turn off the disinfection system.

In some examples, UV-C lights **166** may be mounted on rear side **50** of the upper section **20** of module **3010**. In this location, warming blankets that are hung from the top rear side **50** of the module **3010** between surgical cases may be exposed to UV-C light and disinfected on the side of the blanket contacting the patient. The UV-C lights **166** would be blocked from shining around the room by the blankets hanging in front of the lights, therefore even though personnel may be in the room during case turnover, they will not be exposed to UV-C light. The side of the blankets facing the patient can be disinfected between cases without the need for wiping them off.

In some examples, the various features and inventions described herein for safely and efficiently relocating and housing unrelated equipment in the OR, may be advantageously adapted to house equipment elsewhere in the operating room or elsewhere in the hospital or surgery center. For example, equipment or digital displays used by the surgeon may be housed in a module very similar to module **10** but be preferentially located near the side of the surgical table on the surgical side of the anesthesia screen **30**, rather than near the head of the table. It is anticipated that the various features and inventions described herein for safely and efficiently relocating and housing equipment in the OR, may be used to create modules with different form factors, or modules for different purposes, or modules for use in different locations, or modules for use by different surgical staff, without deviating from the intended scope of this invention.

In some examples, the module **10** of the instant invention may also include the components of an anesthetic gas machine (e.g., **40**). The components of an anesthetic gas machine can include but are not limited to: O_2, N_2O and air supply lines and tanks; piping, valves and flow meters for O_2, N_2O and air; anesthetic gas vaporizers; a circle system breathing circuit with a CO_2 absorption canister and ventilation bag; a mechanical ventilator; pressure and gas concentration monitors. Including the anesthetic gas machine **40** components and functions in the module **10**, advantageously eliminates another piece of equipment from cluttering the operating room and requiring cleaning.

FIG. **33** illustrates an electronic and/or electromechanical system **3300** of a surgical module (e.g. **10**) in accordance with some examples. The system **3300** can include any of the features described in FIGS. **1-32**B to perform techniques **3400-4000** described in relation to FIGS. **34-40**, for example, by using the processor **157**. The system **3300** can include circuitry **3302**. In some examples, the circuitry **3302** can include but is not limited to, electronic circuits, a control module processing circuitry and/or a processor, **3304** (e.g., **157**, FIG. **1**). The circuitry/processor **3302/3304** may be in communication with a memory **3306** and/or a storage device **3308**. A single processor can coordinate and control multiple, or even all the aspects of the system **3300** (module **10**), or multiple processors can control all the aspects of the system **3300** (module **10**). In some examples the storage device **3308** can include at least a portion of the patient's anesthetic record saved thereon. The system **3300** can also include a fan **3310** and a display **3312** (e.g., **38**A, **38**B, **38**C). The system **3300** can also include any of the circuitry and electronic and/or electromechanical components described herein, including but not limited to, blood measuring sensor(s) **3314** (e.g., weight sensor or scale, light sensor, optical sensor, ultrasonic sensor etc.); a urine sensor(s) **3316**, a vacuum pump **3318**, a vacuum pump flow managing device **3320**, an airflow managing device (e.g., a diversion valve for diverting airflow) **3322**. The system **3300** may also include or interface with accessories or other features **3340** such as any of: a wireless tablet **3350**, a surgical mattress **3352**, a surgical compression device **3354**, a dead zone evacuation system **3356**, a sponge counting and detection system **3358** a positive pressure air dilution system **3360**, as well as any of the other systems described herein.

The circuitry **3302**, which in some examples can include processor **3304** of the surgical module **10** can receive information from the various sensors described herein, make various determinations based on the information from the sensors, output the information or determinations from the information for output on the display or wireless tablet, output instructions to provide an alert or an alarm, apply vacuums, power various components such as a fan, actuate actuators, flow managing devices, diversion valves, etc. as described herein. For the sake of brevity, select systems and combinations are described in further detail above and in the example sets provided in the Notes and Various Examples section below. Other embodiments are possible and within the scope of this disclosure.

FIG. **34** illustrates a flow chart showing a technique **3400** for vacuuming air in an operating room using system **3300** (e.g., including any module, such as module **10**, described herein) in accordance with some examples. The technique **3400** can include operation **3402** to receive instructions to power a fan disposed in a surgical module. Operation **3404** can include providing power to the fan to cause air to flow through a specified channel of the module. The specified channel can include a plenum and a vent tube as described herein. Operation **3406** can include receiving additional instructions, operation **3408** determining actions and operation **3410** sending instructions based on the determined actions. Technique **3400** can include additional steps as well as the more detailed steps outlined in Example Set 1 under the Various Notes and Embodiments section.

FIG. **35** illustrates a flow chart showing a technique **3500** for reducing germs in an operating room using system **3300** (e.g., including any module, such as module **10**) in accordance with some examples. The technique **3500** can include operation **3502** including determining whether to activate a disinfection system. Operation **3504** can include activating the disinfection system. Operation **3506** can include deactivating the disinfections system (such as by receiving an instruction to deactivate the system or after a period of time passes). Technique **3500** can include additional steps as well as the more detailed steps outlined in Example Set 2 under the Various Notes and Embodiments section.

FIG. **36** illustrates a flow chart showing a technique **3600** for monitoring waste fluid during a surgery using system **3300** (e.g., including any module, such as module **10**) in accordance with some examples. The technique **3600** can include operation **3602** including receiving information from a sensor about an amount of waste fluid collected over time. Operation **3604** can include determining a delta. Operation **3606** can include outputting the delta, such as for display by an electronic device mounted on the system **3300** or on a wireless tablet device. Operation **3608** can include saving the delta to a storage device. In some examples, the storage device can include at least a portion of the patient's anesthetic record thereon. Technique **3600** can include additional steps as well as the more detailed steps outlined in Example Set 3 under the Various Notes and Embodiments section.

FIG. **37** illustrates a flow chart showing a technique **3700** for applying vacuums using system **3300** (e.g., including any module, such as module **10**), in accordance with some examples. The technique **3700** can include operation **3702** receiving an instruction to secure a module to a floor. Operation **3704** can include applying a vacuum to a suction cup. Operation **3706** can include receiving an instruction to de-couple the suction cup, and based on the instruction, in operation **3708** releasing the vacuum (e.g., by venting to atmosphere) and actuating a lifting element to de-couple the suction cup. Technique **3700** can also include methods of applying the vacuum to waste fluid systems described herein. Technique **3700** can include additional steps as well as the more detailed steps outlined in Example Set 4 under the Various Notes and Embodiments section.

FIG. **38** illustrates a flow chart showing a technique **3800** for measuring urine output from a catheterized patient using system **3300** (e.g., including any module, such as module **10**), in accordance with some examples. The technique **3800** can include operation **3802** receiving information related to urine weight output. Operation **3804** can include determining a volume of urine from the urine weight. Operation **3806** can include saving the urine volume to a storage device. In some examples the storage device can include at least a portion of a patient's anesthetic record stored thereon. Technique **3800** can include additional steps as well as the more detailed steps outlined in Example Set 5 under the Various Notes and Embodiments section.

FIG. **39** illustrates a flow chart showing a technique **3900** for operating a module (e.g., any module herein, such as module **10**) using system **3300**, in accordance with some examples. The technique **3900** can include operation **3902** receiving an instruction to provide air. Operation **3904** sending an instruction to an air pump causing air to be provided to a surgical air mattress or a surgical compression device. Operation **3906** can include receiving an instruction to activate a fan. Operation **3908** can include activating the fan. Operation **3910** can include receiving information about the surgical air mattress or the surgical compression device. Operation **3912** can include determining if the information traverses a threshold. Operation **3914** can include diverting airflow from the fan to the surgical air mattress of the surgical compression device. Technique **3900** can include additional steps as well as the more detailed steps outlined in Example Set 6 under the Various Notes and Embodiments section.

FIG. **40** illustrates a flow chart showing a technique **4000** for filtering air in a surgical field using system **3300** (e.g., including any module, such as module **10**), in accordance with some examples. The technique **400** can include operation **4002** of providing or receiving a first electronic or electromechanical surgical equipment module. Operation **4004** of providing or receiving a second electronic or electromechanical surgical equipment module. Operation **4006** can include containing the waste heat generated by the modules inside of the housing. Operation **4008** can include receiving an instruction. Operation **4010** can include actuating a fan based on the received instruction. Upon operation of the fan, operation **4012** can include receiving airflow into the housing. Operation **4014** can include passing the airflow through a filter. Operation **4016** can include blowing airflow through a vent tube, and operation **4018** can include exhausting at least a portion of the airflow and the waste heat out of the housing. Technique **4000** can include additional steps as well as the more detailed steps outlined in Example Set 7 under the Various Notes and Embodiments section.

FIG. **41** illustrates generally an example of a block diagram of a machine (e.g., of module **10**) upon which any one or more of the techniques (e.g., methodologies) discussed herein may perform in accordance with some embodiments. In alternative embodiments, the machine **4100** may operate as a standalone device or may be connected (e.g., networked) to other machines. In a networked deployment, the machine **4100** may operate in the capacity of a server machine, a client machine, or both in server-client network environments. The machine **4100** may be a personal computer (PC), a tablet PC, a personal digital assistant (PDA), a mobile telephone, a web appliance, a network router, switch or bridge, or any machine capable of executing instructions (sequential or otherwise) that specify actions to be taken by that machine. Further, while only a single machine is illustrated, the term "machine" shall also be taken to include any collection of machines that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein, such as cloud computing, software as a service (SaaS), other computer cluster configurations.

Examples, as described herein, may include, or may operate on, logic or a number of components, modules, or like mechanisms. Such mechanisms are tangible entities (e.g., hardware) capable of performing specified operations when operating. In an example, the hardware may be specifically configured to carry out a specific operation (e.g., hardwired). In an example, the hardware may include configurable execution units (e.g., transistors, circuits, etc.) and a computer readable medium containing instructions, where the instructions configure the execution units to carry out a specific operation when in operation. The configuring may occur under the direction of the execution units or a loading mechanism. Accordingly, the execution units are communicatively coupled to the computer readable medium when the device is operating. For example, under operation, the execution units may be configured by a first set of instructions to implement a first set of features at one point in time and reconfigured by a second set of instructions to implement a second set of features.

Machine (e.g., computer system) **4100** may include a hardware processor **4102** (e.g., a central processing unit (CPU), a graphics processing unit (GPU), a hardware processor core, or any combination thereof), a main memory **4104** and a static memory **4106**, some or all of which may communicate with each other via an interlink (e.g., bus) **4108**. The machine **4100** may further include a display unit **4110**, an alphanumeric input device **4112** (e.g., a keyboard), and a user interface (UI) navigation device **4114** (e.g., a mouse). In an example, the display unit **4110**, alphanumeric input device **4112** and UI navigation device **4114** may be a touch screen display. The display unit **4110** may include goggles, glasses, or other AR or VR display components. For example, the display unit may be worn on a head of a user and may provide a heads-up-display to the user. The alphanumeric input device **4112** may include a virtual keyboard (e.g., a keyboard displayed virtually in a VR or AR setting.

The machine **4100** may additionally include a storage device (e.g., drive unit) **4116**, a signal generation device **4118** (e.g., a speaker), a network interface device **4120**, and one or more sensors **4121**, such as a global positioning system (GPS) sensor, compass, accelerometer, or other sensor. The machine **4100** may include an output controller **4128**, such as a serial (e.g., universal serial bus (USB), parallel, or other wired or wireless (e.g., infrared (IR), near field communication (NFC), etc.) connection to communicate or control one or more peripheral devices.

The storage device **4116** may include a machine readable medium **4122** that is non-transitory on which is stored one or more sets of data structures or instructions **4124** (e.g., software) embodying or utilized by any one or more of the techniques or functions described herein. The instructions **4124** may also reside, completely or at least partially, within the main memory **4104**, within static memory **4106**, or within the hardware processor **4102** during execution thereof by the machine **4100**. In an example, one or any combination of the hardware processor **4102**, the main memory **4104**, the static memory **4106**, or the storage device **4116** may constitute machine readable media.

While the machine readable medium **4122** is illustrated as a single medium, the term "machine readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, or associated caches and servers) configured to store the one or more instructions **4124**.

The term "machine readable medium" may include any medium that is capable of storing, encoding, or carrying instructions for execution by the machine **4100** and that cause the machine **4100** to perform any one or more of the techniques of the present disclosure, or that is capable of storing, encoding or carrying data structures used by or associated with such instructions. Non-limiting machine readable medium examples may include solid-state memories, and optical and magnetic media. Specific examples of machine readable media may include: non-volatile memory, such as semiconductor memory devices (e.g., Electrically Programmable Read-Only Memory (EPROM), Electrically Erasable Programmable Read-Only Memory (EEPROM)) and flash memory devices; magnetic disks, such as internal hard disks and removable disks; magneto-optical disks; and CD-ROM and DVD-ROM disks.

The instructions **4124** may further be transmitted or received over a communications network **4126** using a transmission medium via the network interface device **4120** utilizing any one of a number of transfer protocols (e.g., frame relay, internet protocol (IP), transmission control protocol (TCP), user datagram protocol (UDP), hypertext transfer protocol (HTTP), etc.). Example communication networks may include a local area network (LAN), a wide area network (WAN), a packet data network (e.g., the Internet), mobile telephone networks (e.g., cellular networks), Plain Old Telephone (POTS) networks, and wireless data networks (e.g., Institute of Electrical and Electronics Engineers (IEEE) 4102.11 family of standards known as Wi-Fi®, as the personal area network family of standards known as Bluetooth® that are promulgated by the Bluetooth Special Interest Group, peer-to-peer (P2P) networks, among others. In an example, the network interface device **4120** may include one or more physical jacks (e.g., Ethernet, coaxial, or phone jacks) or one or more antennas to connect to the communications network **4126**. In an example, the network interface device **4120** may include a plurality of antennas to wirelessly communicate using at least one of single-input multiple-output (SIMO), multiple-input multiple-output (MIMO), or multiple-input single-output (MISO) techniques. The term "transmission medium" shall be taken to include any intangible medium that is capable of storing, encoding or carrying instructions for execution by the machine **4100**, and includes digital or analog communications signals or other intangible medium to facilitate communication of such software.

Method examples described herein may be machine or computer-implemented at least in part. Some examples may include a computer-readable medium or machine-readable medium encoded with instructions operable to configure an electronic device to perform methods as described in the above examples. An implementation of such methods may include code, such as microcode, assembly language code, a higher-level language code, or the like. Such code may include computer readable instructions for performing various methods. The code may form portions of computer program products. Further, in an example, the code may be tangibly stored on one or more volatile, non-transitory, or non-volatile tangible computer-readable media, such as during execution or at other times. Examples of these tangible computer-readable media may include, but are not limited to, hard disks, removable magnetic disks, removable optical disks (e.g., compact disks and digital video disks), magnetic cassettes, memory cards or sticks, random access memories (RAMs), read only memories (ROMs), and the like.

The modules described herein with respect to FIGS. **1-42**, and including the machine **4100**, can include features to help with medical aspects including monitoring medication and anesthesia delivery, and other functions, as well as documenting medication and anesthesia delivery, and other functions. In general, doctors and nurses are not interested in replacing themselves and their jobs with automated drug delivery or automated anesthesia systems. However, there is great interest in automated record keeping. Virtually all anesthesia providers would prefer the "old" paper record and a pen to the "new" computer records. Filling out the electronic anesthetic record (EAR) using a computer keyboard, mouse and various menus is widely viewed as a slow, cumbersome and distracting process. The challenge with automated record keeping is automating the data input that documents the numerous activities, anesthesia related events, fluid, gas and medication administration, ventilator settings, pressure off-loading effectiveness, as well as outputs such as blood loss and urine output, that constitute an anesthetic experience.

The second challenge in implementing an automated electronic anesthetic record (EAR) **201** or electronic medical record (EMR) **201** is to force as little change in the caregiver's routine as possible onto the clinicians using this system. Medical personnel tend to be creatures of habit and tradition and they generally do not like change. For example, IV medications are traditionally administered from a syringe and the dose is determined by the caregiver observing the plunger moving relative to a scale printed on the syringe. Maintaining this general technique of drug administration may have the highest probability of acceptance by healthcare users who are typically slow to embrace changes in their routine.

FIG. **42** illustrates an isometric view of a relocation module **4210**. Relocation module **4210** can include any of the features shown and described in FIGS. **1-41**, including module **10** of FIG. **1**. Relocation module **4210** can include an example system for generating an automated electronic anesthetic record (EAR) (e.g., system **228**), wherein the system **228** can be located proximate to a patient. The module **4210** can be a module for housing unrelated electronic and electromechanical surgical equipment (as described, for example, with respect to module **10** of FIG. **1**). However, the module **4210** does not need to include all of the features described herein, and does not need to include all the features of module **10**, although it may. For example, the module **4210**, and any other example modules described herein, need not necessarily be configured to house unrelated electronic and electromechanical surgical equipment in all examples, and other modules can include the system for generating an automated EAR **201**. Like numerals can represent like components, therefore not all of the components are described in further detail.

The module **4210** can include automated EAR system **201** that can include one or more systems (e.g., **228**, **230**) configured to measure (e.g., monitor) and record one or more of functions involved in a surgical anesthetic environment, and can include life support functions. The one or more systems **228**, **230** can measure and record data automatically. However, in some examples, a user may initiate the system to measure and/or record data. These various measurements may be electronically recorded and displayed on the electronic anesthetic record display **226**. Inputs to the automated EAR system **201** may be managed by the anesthetic record input component **224**. The anesthetic record input component **224** can include a touch-screen display that organizes all of the inputs to the EAR **203** into easily accessed and utilized information. In some examples, and as shown in FIG. **42**, the medication identification and measurement system **228** of this disclosure may be located proximate the patient **24**. The control displays for the medication identification and measurement system **228** may include a dedicated display proximate the medication identification and measurement system **228** or may be shared space on the anesthetic record input component **224**. In these locations, the information and controls of the medication identification and measurement system **228** can be viewed by the anesthesiologist or other user, in a single field of vision with the patient and surgical field.

As shown in FIG. **42**, the automated EAR **203** of this disclosure may be attached to and stored within the relocation module **4210**. The relocation module **4210** can conveniently provide direct access to the patient's **24** head and therefore provides convenient mounting support location for the system. In some examples, the components and systems of the automated EAR system **201** of this disclosure can be supported by other mounting supports, including but not limited to an IV pole, a boom-mounted rack system, a wheeled rack system and a surgical table mounting bracket. One or more computers including processing circuitry **157**, of the automated EAR system **201** of this disclosure may be conveniently and safely housed inside the relocation module **4210**. In some examples, it is also anticipated that some or all of the components of automated EAR system **201** of this disclosure could be used in other healthcare settings such as the intensive care unit, the emergency room or on the ward.

In some examples, the touch-screen anesthetic record input component **224** can convert to a qwerty-type keyboard to allow uncommon anesthetic and surgical events or deviations from pre-recorded scripts, to be manually documented. This allows the standard computer keyboard that is used for data entry in most electronic anesthetic records, to be eliminated. Standard keyboards are known to be contaminated with pathogenic organisms and are nearly impossible to clean and decontaminate due to their irregular surfaces. In contrast, the smooth glass or plastic face of a touch-screen monitor is easy to clean with no crevasses to hide organisms.

In some examples, the automated EAR system **201** of this disclosure can include a system for automatically measuring and recording the administration of IV medications. In some examples, the system for automatically measuring and recording the administration of IV medications includes a medication identification and measurement system **228**. As shown in FIG. **42**, the medication identification and measurement system **228** may be advantageously positioned proximate the patient **24**, such as near the patient's head so that medications can be conveniently administered while tending to and observing the patient.

In some examples, the medication identification and measurement system **228** may include one or more sensors, such as one or more of: a barcode reader (e.g., **236**A, FIG. **44**), a radio-frequency identification (RFID) interrogator (e.g., **238**A, FIG. **44**), or any other suitable sensor for accurately and reliably identifying a medication for IV administration. As defined herein, a barcode reader can include any other type of identifying reader, such as, but not limited to, a QR code reader. Likewise, the RFID interrogator can be any type of interrogator and is not limited to those interrogators based on radio frequency.

In some examples, instead of, or in addition to one or more of an RFID interrogator and a barcode reader, the system can receive an input to determine the identity. For example, the system can include one or more of: a sensor configured to identify the one or more IV medications or fluids, or an input configured to receive the identity of the one or more IV medications or fluids, such as via the anesthetic record input component **224**.

In some examples, the barcode reader may be a "computer vision" or "machine vision" camera **236** with the capability of reading barcodes. The term "machine vision" is often associated with industrial applications of a computer's ability to see, while the term "computer vision" is often used to describe any type of technology in which a computer is tasked with digitizing an image, processing the data it contains and taking some kind of action. In this disclosure we will use the terms "machine vision" and "computer vision" interchangeably. Traditionally, machine vision includes technology and methods used to provide imaging-based automatic inspection and analysis, process control, and robot guidance. Machine vision is sometimes used in manufacturing environments. Machine vision refers to many technologies, software and hardware products including processing circuitry, integrated systems and methods.

The inventors have discovered that machine vision can be useful beyond its traditional uses. The inventors discovered that machine vision can be advantageous in implementing an automated EAR **203** because it offers reliable measurements, gauging, object recognition, pattern recognition and liquid fill level measurements. Machine vision does not get tired or distracted. Machine vision excels at quantitative measurement of a structured scene because of its speed, accuracy and repeatability. However, it does require the scene to be structured to perform the desired function.

Machine vision can be very accurate for measuring size of an object at a known distance or the distance of an object of known size. However, it cannot do both. Therefore, in some examples it is important to know the exact location of a syringe (e.g., **200**C, FIG. **45**) for example and thus know the distance from the camera (e.g., **236**A, FIG. **45**) to the syringe (e.g., **200**C, FIG. **45**) in order for the machine vision to calculate the distance of the movement of the plunger within the syringe. This is what we mean by the "scene being structured."

Machine vision may be advantageous for the automated EAR system **201** (EAR) of this disclosure because it "sees" and measures, but does not touch or interfere with the anesthesia provider doing their normal job of injecting medications or administering IV fluids. Further, the same visual image that is used by the machine vision software can be displayed on a screen **226** to give the operator (whose fingers are pushing the plunger of the syringe) a close-up view of the syringe. The machine vision is looking at the same view of the syringe as the operator.

The machine vision camera, or digital camera, can include machine vision software, or the machine vision camera can be in electrical communication with (e.g., operably coupled to) one or more hardware processors, such as processing circuitry **152** and one or more machine-readable mediums, that when implemented on the processing circuitry **157**, can perform the functions described herein. The processing circuitry **157** can be stored in the module **4210**, remote from the module **4210** (e.g. in a wired or wireless manner). As shown in FIG. **33**, the processing circuitry **157** can be or include a processor **3304** that interacts with accessories **3340** of the illustrative module **4210**. For example, systems **228** and **230** can be included as accessories **3340** in communication with other components of the surgical module **3301** as shown and described in FIG. **33**.

In some examples, the RFID interrogator **238** may be either High Frequency (HF) or Near Field (NF) RFID in order to advantageously limit the read-range to a distance of less than 12 inches. In some examples, the RFID read-range may advantageously be limited, such as to less than 8 inches so that only a specific medication injection is identified at any time. In a possibly more preferred example, the RFID read-range may be limited to less than 4 inches to further prevent mis-readings. NF-RFID has a short read-range by definition and the read-range of HF-RFID can be easily limited by restricting the size of the antenna on the tag. In contrast, longer read-range RFID such as Ultra-high Frequency (UHF-RFID) may confusingly interrogate every RFID tag in the operating room and thus be unable to identify which medication is being delivered to the medication identification and measurement system **228**.

FIG. **43** illustrates a plan view of an example of preloaded syringes **200**A and **200**B that can be used with the system of FIG. **42**

The one or more preloaded syringes **200**A and **200**B may be labeled with a unique barcode label **205** or an RFID tag **207** that may identify one or more of the drug, the concentration, the lot number, the expiration date, the manufacturer and other important information. In some examples, a unique barcode label **205** may be a "2-D" barcode label in order to include more information on a smaller area than traditional barcode labels. In some examples, the barcode label **205** or RFID tag **207** includes the drug identifying label **209**A and **209**B for convenient use by the caregiver.

In some examples, the syringes **200**A and **200**B can be filled at the point of use and may be labeled with drug labels **209**A and **209**B and either barcode labels **205** or RFID tags **207** that are removably attached to the drug bottle or vial at the factory or pharmacy. The drug labels **209**A and **209**B and either barcode labels **205** or RFID tags **207** may be easily removed from the drug bottle or vial and adhesively attached to the syringe **200**A or **200**B at the time that the syringe **200**A or **200**B is loaded with the drug by the caregiver. Instead of, or in addition to the barcode labels **205** or RFID tags **207**, any other suitable "tag/reader" system known in the arts, may be used.

FIG. **44** illustrates a side view of an example medication identification and measurement system and a syringe that can be used with the system of FIG. **42**, to monitor drug delivery. FIG. **45** illustrates a cross-sectional view of the medication identification and measurement system and a syringe (not shown in cross-section) of FIG. **44**, taken along line **45**-**45**.

As shown in FIGS. **44** and **45**, the medication identification and measurement system **228**A of this disclosure may include one or more injection portals **211**A. The injection portal **211**A may be a receptacle for accommodating a syringe **200**C in a fixed and known location and can be configured to orient the Luer taper connector **213**A to mate with an injection port **215**. The injection port **215** can be secured within the injection portal **211**A and can be in fluid communication with IV tubing **220**. In some examples, the injection portal **211**A may be a clear tube **216**A that is sized to accommodate the syringe barrel **218**A of a specific size syringe **200**C. In this example, multiple injection portals **211**A would be required to accommodate syringes **200**C of different sizes.

FIG. **46** illustrates a side view of a second example medication identification and measurement system and a syringe that can be used with the system of FIG. **42**. FIG. **47** illustrates a cross-sectional view of the second example of a medication identification and measurement system and the syringe (not shown in cross-section) of FIG. **46**.

As shown in FIGS. **46** and **47**, the injection portal **211**B of the medication identification and measurement system **228**B may be large enough to accommodate syringes **200**D of multiple sizes within the space defined by a real or imaginary injection portal tube **216**B. In this embodiment, accurately orienting the Luer taper connector **213**B to mate with an injection port **215** may be accomplished by one or more orienting members such as one or more spring positioning members **222**A-F that engage with the syringe barrel **218**B to center it in the injection portal **211**B. In some examples, there may be two or more rows of spring positioning members **222**A-F. For example, spring positioning members **222**A, B, E, F may be located near the entrance to the injection portal **211**B and spring positioning members **222**C, D may be located near the injection port **215** to assure accurate positioning for mating with the Luer taper connector **213**B. Spring positioning members **222** may include not only spring wires or metal or plastic spring pieces but any flexible material or combination of materials or shapes that can be deformed by the syringe barrel **218**B entering the injection portal **211**B and retain a memory (e.g., elastically deformable, substantially elastically deformable, resiliently deformable, resilient member) so as to urge the syringe barrel **218**B into a centered position within the space defined by a real or imaginary injection portal tube **216**B.

One possible objective of the spring positioning members **222**A-F is to "automatically" center and align the Luer taper connector **213**B of the syringe **200**B with the injection port **215**, so that the operator can simply and conveniently push the syringe **200**D into the injection portal **211**B and no further manual alignment may be needed. The spring positioning members **222**A-F can also obviate the need for the operator to touch either the Luer taper connector **213**B of the syringe **200**B or the injection port **215**, thus beneficially preventing accidental infectious contamination by the operators' fingers and gloves.

FIG. **48** illustrates a side view of a third example of a medication identification and measurement system and a syringe that can be used with the system of FIG. **42**. FIG. **49** illustrates a cross-sectional view of the third example of a medication identification and measurement system and the syringe **200**E (not shown in cross-section) of FIG. **48**, taken along line **49-49**.

As shown in FIGS. **48** and **49**, syringe barrel **218**C may be centered and held in place by one or more orienting members, such as compression positioning members **242**A, B. The compression positioning members **242**A, B may be urged apart by inserting the syringe barrel **218**C there between. Springs **244**A-D can compress and create a pressure pushing the compression positioning members **242**A,B against syringe barrel **218**C. The compression positioning members **242**A, B shown in the FIGS. **48** and **49** are merely illustrative and many other sizes, shapes, numbers and locations of compression positioning members **242** are anticipated.

Compression positioning members **242**A, B may be simple spring **244**A-D activated devices (e.g., resilient members) as shown in FIGS. **48** and **49** or may be any mechanism that can expand (e.g., resiliently expand) to accommodate syringe barrels of various sizes and urge the syringe barrel **218**C into a centered position within the space defined by a real or imaginary injection portal tube **216**C. This example shows spring **244**A, D activated compression positioning members **242**A, B but many other mechanical activation mechanisms are anticipated. The compression positioning members **242**A, B can be elastically deformable, substantially elastically deformable, resiliently deformable, include one or more resilient members.

Other examples of positioning members designed to hold an inserted syringe **200** in the center of the injection portal **211** and thus orienting the Luer taper **213** for mating with the injection port **215** are anticipated. Positioning the inserted syringe **200** in the center of the injection portal **211** allows the machine vision to work from a known distance and thus calculations of syringe plunger movement can be very accurate.

In some examples, instead of the positioning members holding a syringe centrally, the positioning members can be designed to hold an inserted syringe **200** at a known, but off center position in the injection portal **211**, such as if the injection port **215** is positioned off center in the injection portal **211**. Any arrangement of the positioning members that aligns the inserted syringe **200** at a known position may be provided.

In some examples, and as shown in FIGS. **45**, **47** and **49** the medication identification and measurement system **228**A-C of this disclosure may include one or more "machine vision" cameras **236**A-C that input digital images into a processor having processing circuitry **157**, as shown and described in FIG. **1 157** (FIG. **1**), or **3304** (FIG. **33**), that is programed to analyze machine vision images. In some examples, one of the images that the machine vision cameras **236**A-C may "see" is a barcode label **205** on the syringe **200**C-E, that has been inserted into the injection portal **211**A-C, for identifying the medication in the syringe. As previously noted, the barcode label **205** can identify the brand name and/or generic name of the medication in the syringe. In some examples, the barcode label **205** also may identify one or more of the concentration of the medication, the lot number, the expiration date and other information that may be useful for inventory management.

As shown in FIGS. **44**, **46** and **48**, the medication identification and measurement system **228**A-C of this disclosure can include one or more radio frequency identification (RFID) interrogation antennas **238**A-C that input RFID information into a processor, such as processing circuitry **157** (FIG. **1**) or **3304** (FIG. **33**) that is programed to analyze RFID data. In some examples, the RFID interrogation antennas **238**A-C can interrogate a RFID tag **207** attached to the syringe **200**C-E, that has been inserted into the injection portal **211**A-C, for identifying the medication in the syringe. In some examples, short range RFID such as near field (NF) or high frequency (HF) may be advantageous because they will only detect the syringe that is adjacent to or inside the medication identification and measurement system **228**A-C, and not detect the various other medication syringes that may be sitting on the worktable.

As shown in FIGS. **44**, **46**, **48** the medication identification and measurement system **228**A-C of this disclosure may include a RFID interrogator **238**A-C. In some examples, the RFID interrogator **238**A-C that can include antennas that may be located inside the medication identification and measurement system **228**A-C. In some examples, the RFID interrogator **238**A-C antennas may be located external to but proximate the medication identification and measurement system **228**A-C. As the syringe (e.g., **200**C, **200**D, **200**E) is brought into proximity of the medication identification and measurement system **228**A-C, the RFID interrogator **238**A-C interrogates the RFID tag **207** on the syringe **200**, thereby accurately and reliably identifying a medication for IV administration. In some examples, the RFID tag **207** may include one or more of: the generic and brand name of the drug, the concentration, the lot number, the expiration date, the manufacturer and other important information that may be recorded. In some examples, the generic and brand name of the drug and the concentration of the drug can be displayed in the injection section of the display screen of the anesthetic record input component **224**.

Machine vision is very accurate for measuring the size of an object at a known distance or the distance of an object of known size. However, it cannot do both. Therefore, in some examples it is important to know the exact location of a syringe and thus know the distance from the camera to the syringe in order to accurately calculate the distance of the movement of the plunger within the syringe.

Syringes are available in multiple sizes such as 3cc, 6cc and 12cc, each of which is a different diameter. The machine vision processor must know both the internal diameter of the barrel of the syringe and the distance that the syringe plunger moves down the barrel, in order to calculate the volume of medication injected. The machine vision of this disclosure can measure the diameter of the syringe because it is held in at known distance and in a centered location relative to the machine vision cameras **236**A-C. Alternately, the automated EAR system **201** of this disclosure may be programed to know that the particular hospital uses only Monoject® syringes for example and the internal diameter of each Monoject® syringe size may be pre-programed into the computer. In this case, the machine vision only needs to differentiate 3cc, 6cc and 12cc syringe sizes from each other. The first step for the machine vision processor is to determine the internal diameter of the barrel of the syringe.

In some examples, the machine vision system, including the machine vision camera and a processor **157** (e.g., processing circuitry) in electrical communication with the machine vision camera can visually detect and determine other geometry information about the syringe besides the outside diameter, such as determining the inside diameter, or the inner or outer length of the syringe. The automated EAR system **201** can use the geometry information to determine the size or type of the syringe, or can use the geometry information to calculate a volume of the syringe.

In some examples, as the syringe **200** is advanced into the injection portal **211**A-C, the image of the syringe **200** entering the injection portal **211**A-C is displayed in real time in the injection section of the display screen of the anesthetic record input component **224**. Therefore, the caregiver can watch the syringe advance and engage with the injection port **215**A-C. In some examples, the injection portal tube **216**A or the spring positioning members **222**A-E or the compression positioning members **242**A,B, urge the syringe **200** into position to mate with the injection port **215**A-C but the actual connection can also be observed as it is happening by the caregiver on the display screen of the anesthetic record input component **224**. Even though the caregiver is not physically holding the injection port **215**A-C as they typically would and are they can watch the engagement of the Luer connector **213** with the injection port **215**A-C on a display screen, the view is essentially identical to the thousands of injections that they have made during their career. In some examples, the actual image of the syringe can be displayed on the display screen **226**, while in other examples the data obtained by the camera can be converted to a representation of the syringe displayed on the display screen **226**.

In some examples, once the syringe **200** is securely connected to the injection port **215**A-C, the caregiver pushes on the plunger **246**A-C of the syringe **200**C-E, injecting the medication into the injection port **215**A-C and IV tubing **220**A-C. The caregiver can visualize the plunger seal **248**A-C move down the syringe barrel **218**A-C and can determine the volume of medication injected by the graduated markings on the syringe C-E. Thus, the engagement of the Luer connector **213** with the injection port **215**A-C and the injected volume are observed by the caregiver on the display screen **226** of the anesthetic record input component **224** and the traditional method and routine of injection is minimally altered by the EAR system **201** of this disclosure.

In some examples, the processing circuitry **157** or a computer may also simultaneously generate a running total of the volume and dosage of the injected medication and display these numbers on the display screen **226** of the anesthetic record input component **224**. In some examples, the processing circuitry **157** or a computer may also simultaneously generate its own graduated scale and superimpose the scale on the image of the syringe **200**C-E or next to the image of the syringe **200**C-E, for added visual clarity of the injected volume and dose.

In some examples, the machine vision determination of the injected volume may be calculated by multiplying the internal cross-sectional area of the syringe (πr^2) by the distance that the syringe plunger moves. The radius of the syringe may be determined in one or more ways. For example, the machine vision function may determine that the syringe approximates a 3cc or 12 cc syringe and the computer is programed to know that the hospital uses a specific brand of syringes and the internal diameter (radius) of each of these syringe sizes is precisely known. Another example may require the machine vision to measure the outer diameter of the syringe and then subtract an approximated wall thickness from the measured diameter to determine the internal diameter.

In some examples, the machine vision determination of the distance that the syringe plunger moves may be by "observing" the movement of the black rubber plunger seal against the visible scale printed on the syringe. In this example, the machine vision is programed to recognize the markings on the syringe.

In some examples, the machine vision determination of the distance that the syringe plunger moves may be by observing the movement of the black rubber plunger seal relative to a scale calculated by the machine vision computer. The geometrical calculation of the scale that determines the distance that the syringe plunger moves may be easiest along the widest part of the syringe that corresponds with the center of the syringe, which is a known distance from the machine vision camera. Alternatively, the computer-constructed scale may be applied to the side of the syringe facing the camera, if the radius of the syringe is subtracted from the known distance to the center of the syringe in order to calculate the distance from the machine vision camera to the near side of the syringe.

In some examples, the movement of the black rubber plunger seal of the syringe is clearly identifiable by the machine vision camera and a scale to determine the distance moved by the plunger can either be "visualized" or constructed by the machine vision computer. Multiplying the distance that the plunger seal moves by the known or measured internal diameter of the syringe and thus cross-sectional area of the plunger seal, allows the processing circuitry **157** or an anesthetic record input computer **203**B (FIG. **42**) in electrical communication with the processing circuitry **157** to calculate an accurate injected volume. The anesthetic record input computer **203**B may then display the measured injection volume and dosage on the display screen **226** of the anesthetic record input component **224**. Without interfering with or changing the anesthesiologists' normal or traditional medication injection routines, an unobtrusive machine vision camera and computer can "observe" the medication injections and automatically record them in the electronic anesthetic record.

In some examples, the injected volume of medication may be determined by other methods. For example, non-visual optical sensing is well known in the arts. A light source shines on one or more light sensitive elements such as photodiodes for example, and the position of the plunger of the syringe can be roughly determined by the obstruction of the light beam by the plunger. Other fluid measurement methods include adding magnetic material to the syringe plunger and detecting movement of the plunger with a magnetic proximity sensor. Alternatively, fluid flow may be measured with fluid flow meters in the IV fluid stream. These examples are not meant to be an exhaustive list but rather to illustrate that there are alternative technologies to machine vision, for noncontact measurement of fluid flow from a syringe that are anticipated in this disclosure.

Securing the injection port **215** within the injection portal **211** prevents the caregiver from touching the injection port **215**. Normally caregivers wear gloves to protect themselves from infectious contaminates from the patient and operating room and their gloves are nearly always contaminated. Anything they touch will be contaminated. They typically pick up and hold the IV injection port **215**A-C with one hand while inserting the Luer taper connector **213** of the syringe **200** into the injection port **215**A-C. In the process, the injection port is frequently contaminated with pathogenic organisms from their gloves that can enter the patient's blood stream with the next injection, causing serious infections. It is therefore advantageous from the infection prevention point of view, if the Luer connection and injection can be accomplished while never touching the injection port **215**A-C.

In some examples as shown in FIGS. **44**, **46** and **48** the medication identification and measurement system **228**A-C of this disclosure may include one or more ultraviolet lights **240**A-J that shine on the injection port **215**A-C. The one or more ultraviolet lights (UV) are inside the medication identification and measurement system **228**A-C, keeping the injection portal **211**A-C and the injection port **215**A-C disinfected. In some examples, the ultraviolet lights **240**A-J may preferably be in the UV-C part of the spectrum. UV-C light has been shown to have superior germicidal powers over other parts of the UV spectrum. The UV lights **240**A-J may shine continuously or intermittently. By making the injection port **215**A-C untouchable because it is inside the medication identification and measurement system **228**A-C and radiating the injection port **215**A-C with UV-C light, the injection port **215**A-C should be effectively disinfected between each injection and eliminate injection port contamination as a source of bloodstream infection.

In some examples as shown in FIG. **42**, a worktable **250** may be located proximate the head of the patient. In some examples, the worktable **250** may be incorporated into relocation module **4210**. In some examples, the worktable **250** may be used for holding the various medication syringes **200**F-H being used for the surgical anesthetic. In some examples, the Luer tapers **213** of the various medication syringes **200**F-H are simply capped in the traditional way while sitting on the worktable between injections.

In some examples as shown in FIG. **42**, the various medication syringes **200**F-H are not capped between injections in order to prevent accidental contamination of the Luer tapers **213** by the contaminated fingers or gloves of the healthcare provider, during the capping process. In this example, the uncapped Luer tapers **213** of syringes **200**F-H may be placed under a protective overhang **252** that is 1-2.5 in. above and along the rear of the worktable **250**. In some examples, ultraviolet lights **240**H may be attached on the underside of the protective overhang **252**, shining down on the exposed Luer tapers **213** of syringes **200**F-H. In some examples, the ultraviolet lights **240**H are preferably in the UV-C part of the spectrum. Any of the UV lights **240**A-J may shine continuously or intermittently.

In some examples, the uncapped Luer tapers **213** of syringes **200**F-H are kept sterile by eliminating capping and thus not inadvertently touching Luer tapers **213** of syringes **200**F-H, and by storing the uncapped Luer tapers **213** of syringes **200**F-H under a protective overhang **252**, and by radiating the uncapped Luer tapers **213** with UV-C light.

FIG. **50** illustrates an example injection port cassette that can be used with the system of FIG. **42**, as detailed in **45**, **47** and **49**. As shown in FIG. **50**, the injection port **215**D may be mounted on an injection port cassette **254** in order to make the attachment to the medication identification and measurement system **228**A-C easier and more secure. The injection port cassette **254** may be a piece of molded plastic onto which the injection port **215**D and IV tubing **220** may be attached. The injection port cassette **254** may be shaped and sized to fit into a slot in the medication identification and measurement system **228**A-C. When the injection port cassette **254** is fit into a slot in the medication identification and measurement system **228**A-C, the injection port **215**D can be positioned substantially in the center of the injection portal **211** for mating with the Luer tapers **213**. The injection port cassette **254** can also be configured to be removed intact from the medication identification and measurement system **228**A-C so that the patient can be transferred and the IV tubing **220** can be moved with the patient and continue to operate normally.

In some examples, and as shown in FIG. **50**, the injection port cassette **254** can include an IV bypass channel **256** in the IV tubing **220**. The IV bypass channel **256** can allow the IV fluids to flow unencumbered by the medication injection apparatus. The injection port cassette **254** can include a medication channel **258** in the IV tubing **220** and, the medication channel **258** may include one or more stop-flow clamps **260**A, B. The stop-flow clamps **260**A, B may be activated by anesthetic record input component **224** and anesthetic record computer if a medication error is noted. The stop-flow clamps **260**A, B may be powered by electromechanical solenoids that squeeze the IV tubing flat obstructing the flow. Other electromechanical flow obstructers are anticipated.

In some situations, such as when administering a drug to a patient allergic to that drug, or administering potent cardiovascular drugs to a patient with normal vital signs, or administering a drug with a likely mistaken identity, the automated anesthetic record computer of this disclosure may automatically activate the stop-flow clamps **260**A, B to compress the medication channel **258** tubing upstream and/or downstream from the injection port **215**D. Compressing the IV tubing both upstream and downstream from the injection port **215**D prevents the injection of any medication into the IV tubing. An alert to the adverse condition of the injection may be displayed on the anesthetic record input component **224**, where the stop-flow condition can be overridden by the operator touching a manual override switch on the anesthetic record input component **224**, if the injection was not erroneous. While the stop-flow can occur in the medication channel **258**, the IV fluid flow can continue normally in the parallel bypass channel **256**.

The stop-flow clamps **260**A, B can allow the microprocessor (e.g., processor, hardware processing circuitry) of the anesthetic record input component **224** to not only warn the operator of a pending medication error, but physically prevent the injection. Equally important is that the stop-flow clamps **260**A, B can be quickly released by the operator touching a manual override switch in the event that the apparent error was in fact a planned event.

FIG. **51** illustrates a side view of an example IV fluid identification and measurement system **230** that can be used with the systems of FIGS. **42-49**, and injection port cassette of FIG. **50**. In some examples, the automated EAR of this disclosure includes a system for automatically measuring and recording the administration of IV fluids. As shown in FIGS. **42** and **51**, the automated EAR **201** can include an IV fluid identification and measurement system **230**. In some examples, the IV fluid identification and measurement system **230** can be mounted onto module **4210**. Alternately, the IV fluid identification and measurement system **230** may be mounted to an IV pole or racking system independent from the module **4210**. The system for automatically measuring and recording the administration of IV fluids is not limited to use in anesthesia or in the operating room, but has applicability for use throughout the hospital and other health care settings, including but not limited to the ICU, ER, wards, rehabilitation centers and long term care settings.

In some examples, the IV fluid identification and measurement system **230** may be configured to accommodate one or more IV bags of IV fluid **232**A, B. Each bag of IV fluid can include a drip chamber **234**A, B and IV tubing **220**D, E. IV flow rates may be controlled with the traditional manually operated roller clamp that variably pinches the IV tubing **220**D, E to control or even stop the flow of IV fluids. In some examples, IV flow rates may be controlled with the automatically operated electromechanical flow rate clamps

278 that variably pinch the IV tubing **220**D to control or even stop the flow of IV fluids. The automatically operated electromechanical flow rate clamps **278** may be controlled by the electronic anesthetic record computer in module **4210** or by a microprocessor (e.g., processor, hardware processing circuitry) located within the IV fluid identification and measurement system **230**.

In some examples, the system for automatically measuring and recording the administration of IV medications and fluids **228**, **230** includes one or more of a barcode reader and an RFID interrogator (such as **236**D, E) for accurately and automatically identifying a fluid for IV administration. Because of the close proximity to the adjacent bags, barcode identification may be preferable in order to prevent an RFID interrogator from reading the RFID tag on a neighboring bag. In some examples, as shown in FIG. **51**, one or more barcode labels **205**B, C may be applied to the IV bags **232**A, B in a location where they can be read by a barcode reader or machine vision camera **236**D, E, or another machine vision camera located in a suitable position. In some examples, a dedicated barcode reader or a machine vision camera may be positioned adjacent the barcode label **205**B, C location, specifically for reading the barcode label **205**B, C.

In some examples, the drip chamber **234**A, B of the IV set can be positioned adjacent the one or more machine vision cameras **236**D, E. In some examples, a standard background **268**A, B may be positioned on the opposite side of the drip chamber **234**A, B from the machine vision cameras **236**D, E. The standard background **268**A, B may be a plain background or may be an advantageous color, pattern, color design or illumination that highlights each of the falling drops, for easier identification by the machine vision software. The machine vision software can include one or more machine-readable mediums that when implemented on hardware processing circuitry of the system or in electrical communication with the system, can perform the functions described herein.

In some examples, the machine vision software is programed to cause the processing circuitry **157** to look for a fluid meniscus **264**A, B in the drip chamber **234**A, B. In this case "seeing" a fluid meniscus **264**A, B indicates that there is fluid in the drip chamber **234**A, B and therefore the IV bag **232**A, B is not empty, and air is not inadvertently entering the IV tubing.

In some examples, if the machine vision software fails to "see" a fluid meniscus **264**A, B meaning that the drip chamber **234**A, B is empty and thus the IV bag **232**A, B is empty, stop-flow clamps **260**C, D may be automatically activated to compress the IV tubing **220**D, E in order to prevent air from entering the IV tubing **220**D, E. In some examples, the empty IV bag condition detected by the machine vision software can be displayed as an alert to the caregiver on the anesthetic record input component **224**.

The combination of the machine vision camera **236**D, **236**E in electrical communication with processing circuitry (e.g., **157**, FIGS. **1** and **42**, processor **3304**, FIG. **33**) can count the number of drops of fluid per unit of time in a drip chamber **234**A, B to calculate or to estimate the flow rate of an IV. The size of the drip chamber inlet orifice determines the volume of liquid in each drop. The inlet orifices of standard drip chambers are sized to create drops sizes that result in **10**, **12**, **15**, **20**, **45** and **60** drops per ml. Given a particular drop volume (size), **10** drops per ml for example, the system can count the number of drops falling in a known period of time and use that data to calculate or to estimate the flow rate. If these estimates were attempted by a human, they may be less accurate at higher flow rates (higher drop counts) because the drops are so fast, it can be difficult to count the drops. Eventually, at even higher flow rates the individual drops become a solid stream of fluid and the flow rate cannot be visually estimated.

In some examples, the machine vision system is configured to look for falling drops of fluid **262**A, B within the drip chamber **234**A, B. When drops have been identified, the machine vision system (e.g., machine vision camera **236**D or **236**E operably coupled to processing circuitry **157**) may first measure the diameter of the drop to determine which of the standard drop sizes or volumes it is counting. Most hospitals standardize on several infusion set sizes, 10, 20 and 60 drops per cc for example. Therefore, when these limited choices of infusion set brands and sizes have been programed into the computer, the machine vision system only needs to differentiate between these choices, which is much easier than accurately measuring the diameter of the drops. Unlike the human eye, the machine vision can accurately count the falling drops even at high flow rates to calculate an IV fluid flow rate.

In some examples, the machine vision system, including the machine vision cameras **236**D, E and the machine vision software implemented by hardware processing circuitry **157** does not "see" falling drops. In this situation, either the fluid is flowing in a steady stream that is not identifiable by the machine vision software or the fluid has stopped flowing. In some examples, these two opposite conditions can be differentiated by inserting a floating object **266**A, B into the drip chambers **234**A, B. In some examples, the floating object **266**A, B may be a ball-shaped float **266**A, B and in some examples the float may be patterned or multi-colored to more easily identify movement or spinning of the float. In some examples, if the machine vision system cannot identify falling drops, it then looks to the floating object **266**A, B for additional information. If the floating object **266**A, B is not moving or spinning, the fluid flow has stopped. If the float **266**A, B is moving or spinning and drops cannot be identified, the fluid is flowing in a steady stream and the flow rate cannot be measured by machine vision.

In some examples, the IV fluid identification and measurement system **230** may be configured to accommodate one or more bags of IV fluid **232**A, B and each of these IV bags may be hanging from an electronic IV scale **272**A, B. The electronic IV scale **272**A can measure the combined weight of the IV bag and fluid **232**A, the drip chamber **234**A and the IV tubing **220**D. The electronic IV scale **272**B can measure the weight or combined weight of one or more of the IV bag and fluid **232**B, the drip chamber **234**B, the IV tubing **220**E and the pressure infuser **274**. In both of these examples, the electronic IV scale **272**A, B can accurately measure the change in combined weight that occurs due to the drainage of the IV fluid from the IV bag. The change in weight per unit time can be converted to flow rates by processing circuitry **157** in electrical communication with the electronic IV scale **272**A, **272**B, for example, by the anesthetic record computer **203**B and displayed on the anesthetic record input component **224**.

In some examples, the calculated flow rates for each IV bag **232**A, B may also be displayed on one or more digital flow-rate displays **276**A, B mounted on the IV fluid identification and measurement system **230**. The digital flow-rate displays **276**A, B may be small LED or LCD display screens that conveniently tell the operator the flow rate while they are manually adjusting the flow rate near the IV bags **232**A, B and drip chambers. **234**A, B. The digital flow-rate displays **276**A, B are particularly convenient when the IV fluid identification and measurement system **230** is a free standing entity mounted on an IV pole for example while being used on the ward or ICU.

In some examples, when the falling drops **262**A, B cannot be detected and yet the floats **266**A, B are moving or spinning, the fluid is determined to be flowing in a steady stream and the flow rate cannot be measured by machine vision. In this case the anesthetic record computer may automatically query the change in weight per unit time as measured by the electronic IV scale **272**A, B to determine the IV flow rate. At high flow rates, the change in weight per unit time as measured by the electronic IV scale **272**A, B will most likely be more accurate than counting drops, in determining the IV flow rate.

The IV flow rate as determined by the change in weight per unit time can also be compared to the IV flow rates determined by counting drops to verify the accuracy of each method. Without interfering with or changing the anesthesiologists' normal or traditional IV routines, an unobtrusive machine vision camera and computer can "observe" the IV flow rates and automatically record them in the electronic anesthetic record.

FIG. **52** illustrates side view of an example of a gas flow meter system **289** that can be used with the system of FIG. **42**. FIG. **53** illustrates a top view of the example gas flow meter system **289** of FIG. **52**. FIG. **54** illustrates a side view of an example anesthetic gas vaporizer monitoring system including a vaporizer **288** that can be used with the system of FIG. **42**.

Some ventilation gas flow meters on anesthesia machines are made by floating a small metal float in a gas stream flowing through a glass tube. The inside of the glass tube is tapered from narrow at the bottom to wider at the top, thus requiring higher flow rates to raise the float higher in the glass tube. As shown in FIGS. **52**, **53**, the gas flow meter tubes **280**A, B have floats **282**A, B suspended by the gas flow within the tubes **280**A, B. The gas flow in each gas flow meter tube **280**A, B is controlled by the flow control valves **286**A, B. The height of the floating effect correlates with the flow rate of the gas within the tube and can be measured by comparing the height of the floats **282**A, B to the gas flow rate scales **284**A, B located adjacent the flow meter tubes **280**A, B. In these examples, float **282**A indicates approximately 3.5 li/min of gas flow and float **282**B indicates approximately 2 li/min of gas flow.

In some examples, the automated EAR system **201** of this disclosure can use machine vision to unobtrusively "observe" the flow rate of the ventilation gas flow meters (e.g., **289**; FIG. **42**, **52**, **53**). In some examples, the machine vision camera **236**D is located far enough from the gas flow meter tubes **280**A, B to have a "view" of the entire tube. The camera **236**D and computer can differentiate the float **282**A, B from the background and accurately locate float **282**A, B within the gas flow meter tubes **280**A, B. The machine vision computer is programed with a scale that corresponds to the gas flow rate scales **284**A, B. Comparing float **282**A, B locations with the scale programed into the computer, accurately determines the gas flow rate within the gas flow meter tubes **280**A, B. Without changing or interfering with the anesthesiologists' normal or traditional gas control routines, an unobtrusive machine vision camera and computer can "observe" the gas flow rates and generate data that is automatically recorded in the electronic anesthetic record, or used to calculate other data that is recorded (e.g., stored) in the electronic anesthetic record **203**A.

In some examples, the automated EAR system **201** of this disclosure uses machine vision to unobtrusively "observe" the concentration of the anesthetic gas from the anesthetic gas vaporizer. As shown in FIG. **54**, the anesthetic gas vaporizer **288** can include a canister with a rotating vaporizer control knob **290** used to adjust the concentration of the anesthetic gas flowing from the vaporizer **288**. For example, the control knob **290** can be located on the top of the vaporizer **288**, but other configurations such as locating the control knob **290** on the side of the vaporizer **288** are possible. In some examples, a machine vision camera **236**E is positioned on the anesthesia machine or on the module **4210** so that it can "see" either the numerical scale printed on the control knob **290** or a scale programed into the computer that corresponds to the numerical scale printed on the control knob **290**. The machine vision camera and computer can accurately determine the concentration of delivered anesthetic gases. Without changing or interfering with the anesthesiologists' normal or traditional anesthetic gas control routines, an unobtrusive machine vision camera and computer can "observe" the anesthetic gas flow concentrations and automatically record them in the electronic anesthetic record.

In some examples, the automated EAR system **201** of this disclosure accepts data from the electronic scales and hematocrit determinations of the fluid suction canisters or bags disclosed herein. The calculated blood loss is automatically recorded in the EAR **203**A and displayed on the anesthetic record input component **224** and the electronic anesthetic record display **226**.

In some examples, the automated EAR system **201** of this disclosure is in electrical communication with and is configured to accept (e.g., receive) data from the electronic urine bag scales disclosed herein. The calculated urine output can be automatically recorded in the EAR **203**A and displayed on the anesthetic record input component **224** and the electronic anesthetic record display **226**.

In some examples, the automated EAR system **201** of this disclosure is in electrical communication with and is configured to receive data from an IV extravasation monitor that is either hard wired or wirelessly connected to the patients' IV site. An IV extravasation monitor can be designed to detect inadvertent leakage from the IV site into the surrounding tissue, which generally means that the IV is "blown" and some infused drugs could cause significant tissue damage. One example of an IV extravasation monitor previously disclosed by this inventor includes the placement of one or more thermometers (thermocouples or thermistors) adjacent the IV catheter entrance site into the vein and adjacent the tip of the IV catheter. A thermometer is programed to continuously measure the temperature difference (ΔT) between these two sites. If the ΔT changes over time, it can be assumed that leakage of cool or warm IV fluids is occurring at either the catheter entrance site into the vein or that the tip of the catheter has eroded through the vein wall. The cool IV fluids will cool the tissue and the adjacent thermometer will detect a cooling of the tissue at that site. When an increasing temperature differential is detected, an alarm will be activated and the automated EAR **203**A of this disclosure will be notified.

In some examples, the automated EAR system **201** of this disclosure is in electrical communication with and is configured to receive data from a patient support mattress. In some examples, the patient support mattress is an air mattress. One example of a patient support air mattress is disclosed in U.S. Pat. Nos. 9,962,122 and 10,433,792, incorporated into this disclosure in their entirety. The air mattress may include an air pressure sensor to detect the air pressure within the air chambers of the system. The first requisite is that the patient support mattress is not "hammocking," in other words that the upper surface is not stretched tight enough to prevent the body part from sinking into the air mattress. The second requisite is that a body part is not "bottoming out" on the hard surface below the patient support mattress. The third requisite is that the air chambers are partially inflated in order to allow the patient to sink into the mattress. If these three requisites are satisfied, the pressure per square area of skin cannot be greater than the pressure per square area within the air chamber, which is the definition of the measured air pressure within the air chamber. This skin pressure safety monitor is both simple and inexpensive and more accurate compared to other electronic pressure detection systems for avoiding pressure injuries.

In some examples, when the patient is sunk into the patient support air mattress disclosed in U.S. Pat. Nos. 9,962,122 and 10,433,792, the air pressure within the air chambers may be measured and recorded. If the measured air pressure per square area is less than the capillary perfusion pressure of the skin, it can be assumed that there are no areas of the patient's skin where blood flow has been occluded by pressure from the support mattress. In other words, if the requisite criteria listed above are satisfied, the air pressure in the air chambers of the mattress serves as a reliable monitor of the maximum pressure applied to any dependent skin surface. This air pressure can be automatically recorded in the EAR **203**A and displayed on the anesthetic record input component **224** and the electronic anesthetic record display **226**, providing assurance to the caregiver and documentation that the patient's skin has been adequately protected from pressure injury.

In some examples, the automated EAR of this disclosure is in electrical communication with and is configured to receive data from a system for automatically counting and detecting surgical sponges. A system for automatically counting and detecting surgical sponges has been previously disclosed in US Patent Application 2015/0216610 and U.S. Pat. No. 10,461,397 which are incorporated into this disclosure in their entirety. These disclosures by this inventor describe a system of incorporating RFID tags into surgical sponges. Each of the RFID tags and thus each of the sponges is interrogated as the sponges enter the sterile surgical field and each is individually recorded. Later, each of the sponges is interrogated as the sponges leave the sterile surgical field and each is individually recorded. This electronic RFID sponge counting is presumably more accurate and reliable than the manual sponge count by the nurse. If a discrepancy is noted in the sponge count, RFID antennae may be used to detect the location of the missing sponge, even if it is still in the patient.

In some examples, the data from the RFID sponge counting is automatically entered into the EAR **203**A or electronic surgical record. An accurate sponge count can assure the care providers that a "retained surgical item" has not occurred. The itemized sponge count also aids in inventory management and billing.

In some examples, the automated EAR system **201** of this disclosure is in electrical communication with and is configured to receive data from a Sequential Compression Device (SCD) that may be housed within module **1410**. An SCD is an inflatable leg wrap that sequentially applies pressure to the legs of a patient during surgery in order to prevent deep vein thrombosis (DVT). The use of the SCD and the applied air pressures may be automatically entered into the EAR **203**A or electronic surgical record. Documentation that SCD was used during surgery also aids in inventory management and billing.

In some examples, the automated EAR system **201** of this disclosure is in electrical communication with and is configured to receive data from an Electrosurgical Unit (ESU) that may be housed within module **1410**. The ESU use history and settings may be automatically entered into the EAR **203**A or electronic surgical record. Documentation that SCD was used during surgery also aids in inventory management and billing.

In some examples, the automated EAR system **201** of this disclosure is in electrical communication with and is configured to receive data from a peritoneal insufflator that may be housed within module **1410**. Peritoneal insufflators are used to insufflate the patient's peritoneum during laparoscopic and robotic surgery. The insufflator use history and pressure settings may be automatically entered into the EAR **203**A or electronic surgical record. Documentation that insufflator was used during surgery also aids in inventory management and billing.

When the aforementioned data has been automatically recorded into the EAR **203**A, documentation steps by the healthcare providers is drastically simplified. In some examples, the only remaining items in need of documentation are the special events such as intubation, extubation, surgical incision, going on bypass, going off bypass and surgical mishaps.

In some examples, the automated EAR system **201** of this disclosure captures anesthetic event data by capitalizing on the fact that anesthesiologists, surgeons and nurses compulsively tend to meticulously follow their personal routines. For each "event" they will inevitably follow their routine and use the same description each time to record the event. For example, a particular anesthesiologist may routinely intubate all adult male patients with a Miller 3 laryngoscope and an 8.0 endotracheal tube unless there is an abnormality. The provider's routine written record of the event may state, "Miller 3, 8.0 ET taped 23 cm at teeth, atraumatic, BBS" and that provider will write the same description every time. The provider has done a thousand of these intubations and believes their way is best and therefore there is no need for experimentation or unique descriptive procedure notes. This observation of routine applies to surgeons as well—both in the details of each surgical procedure and the dictated surgical note describing the surgical procedure. Therefore, the automatic EAR **203**A, or EAR computer **203**B can be programed to "automatically" document most procedures and special events if it knows who the provider is and a few facts about the patient.

For example, if the EAR system **201** knows who is providing the anesthesia, knows their preferences, knows how they prefer to describe anesthesia events such as intubation and knows that the patient is an adult male, it can "automatically" enter anesthesia providers' standard description of the intubation event into the record and will be correct more than 95% of the time. Therefore, the anesthesia provider simply indicates on the anesthetic record input component **224** that intubation occurred by touching the intubation icon and the event will be automatically recorded and the time noted. In the unusual event of a patient abnormality or a deviation from their normal routine, the anesthesia provider can manually enter the variant information, to provide an accurate record. In some examples, the relative rarity of data being manually entered into the EAR **203**A allows for the elimination of the computer keyboard and mouse, to be replaced by an easy-to-clean touch screen display.

The automated EAR system **201** of this disclosure captures anesthetic event data but it must be noted that the same technologies described herein for capturing anesthetic event data can be used throughout the hospital or outpatient health care system to capture and record medication administration, IV fluid administration, vital signs and patient monitor inputs, provider events and other data. Non-operating room heath care locations are intended to be included within the scope of this disclosure. While this disclosure focuses on the totality of functions offered by module **10**, **1410**, each of the individual functions can be offered independently of module **10**, **1410**.

The use of the term Electronic Anesthetic Record as defined herein can include an electronic surgical record, or an electronic medical record, and is not limited to anesthetic or surgical applications. Aspects of the modules described herein can also be employed in recovery, hospital room and long-term care settings.

In an example, the module **4210** of FIGS. **42**-**54**, like module **10** of FIG. **1**, can include a housing having a lower section **14** and a tower-like upper section **18**, wherein the lower section **14** is configured to house unrelated waste heat-producing electronic and electromechanical surgical equipment, and wherein the tower-like upper section is located on top of the lower section. The module **4210** can also include a cowling that substantially confines waste heat generated by the unrelated waste heat-producing electronic and electromechanical surgical equipment. In addition, the module **4210** can include a system for monitoring the administration of one or more IV medications and fluids **228**, **230**. The system **228**, **230** can include: a barcode reader or an RFID **238** interrogator configured to identify the one or more IV medications or fluids; a machine vision digital camera **236** to capture an image of one or more of a syringe **200** or a drip chamber **234**; processing circuitry **157** (**3304**, FIG. **33**) operably coupled to the barcode reader **236** or the RFID interrogator **238** to receive the identity of the one or more IV medications or fluids, the processing circuitry **157** operably coupled to the machine vision digital camera to receive the captured image and determine a volume of medication administered from the syringe or fluid administered from an IV bag based on the image; and a display **226** operably coupled to the processing circuitry **157**, the display **226** configured to receive instructions from the processing circuitry **157** to output the identity and determined volume of medication administered from the syringe or fluid administered from an IV bag.

The above detailed description includes references to the accompanying drawings, which form a part of the detailed description. The drawings show, by way of illustration, specific embodiments in which the invention can be practiced. These embodiments are also referred to herein as "examples." Such examples can include elements in addition to those shown or described. However, the present inventors also contemplate examples in which only those elements shown or described are provided. Moreover, the present inventors also contemplate examples using any combination or permutation of those elements shown or described (or one or more aspects thereof), either with respect to a particular example (or one or more aspects thereof), or with respect to other examples (or one or more aspects thereof) shown or described herein.

In this document, the terms "a" or "an" are used, as is common in patent documents, to include one or more than one, independent of any other instances or usages of "at least one" or "one or more." In this document, the term "or" is used to refer to a nonexclusive or, such that "A or B" includes "A but not B," "B but not A," and "A and B," unless otherwise indicated. In this document, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Also, in the following claims, the terms "including" and "comprising" are open-ended, that is, a system, device, article, composition, formulation, or process that includes elements in addition to those listed after such a term in a claim are still deemed to fall within the scope of that claim. Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects. The terms approximately, about or substantially are defined herein as being within 10% of the stated value or arrangement.

The above description is intended to be illustrative, and not restrictive. For example, the above-described examples (or one or more aspects thereof) may be used in combination with each other. Other examples can be used, such as by one of ordinary skill in the art upon reviewing the above description. The Abstract is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. Also, in the above Detailed Description, various features may be grouped together to streamline the disclosure. This should not be interpreted as intending that an unclaimed disclosed feature is essential to any claim. Rather, inventive subject matter may lie in less than all features of a particular disclosed example. Thus, the following claims are hereby incorporated into the Detailed Description as examples or examples, with each claim standing on its own as a separate example, and it is contemplated that such examples can be combined with each other in various combinations or permutations. The scope of the invention should be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.

Notes and Various Examples

Each of these non-limiting examples may stand on its own, or may be combined in various permutations or combinations with one or more of the other examples. The examples are supported by the preceding written description as well as the drawings of this disclosure.

Example Set 1

Example 1 is a method of vacuuming air in an operating room, the method comprising: receiving, using circuitry, one or more instructions to provide power to a fan disposed in a surgical module, wherein the housing is configured to store unrelated electronic and electromechanical surgical equipment within the housing; and providing power to the fan, using the circuitry, wherein providing power to the fan causes air from a surgical field to be collected into a plenum through an inlet vent, and causes heat generated by the electronic surgical equipment to be collected into the plenum, wherein providing power to the fan causes the collected air and heat to create an airflow that passes through a specified channel in the housing, and wherein the controlled airflow causes the equipment stored in the module to be cooled and the airflow to be cleaned before being exhausted out of the housing through an outlet vent.

In Example 2, the subject matter of Example 1 includes, wherein receiving the one or more instructions, using the circuitry, includes receiving an instruction to actuate a noise canceling device, wherein the noise canceling device is configured to cancel at least a portion of a noise generated by the fan.

In Example 3, the subject matter of Examples 1-2 includes, wherein the plenum substantially separates the air collected through the inlet vent from being in contact with the electronic and electromechanical equipment.

In Example 4, the subject matter of Examples 1-3 includes, wherein the circuitry includes processing circuitry, the method further comprising: receiving an instruction, using the processor, to divert at least a portion of the airflow to an air mattress; and sending an instruction, using the processor, to a flow management device to divert at least portion of the airflow to the air mattress; and diverting, using the flow management device, at least a portion of the airflow to the air mattress.

In Example 5, the subject matter of Examples 1-4 includes, wherein the circuitry includes a processor, the method further comprising: sensing, using a sensor, information related to an air mattress; receiving, using the processor, the information from the sensor; determining, using the processor and the information received from the sensor, to divert at least a portion of the airflow to the air mattress; and sending an instruction; using the processor, to a flow management device to divert at least a portion of the airflow to the air mattress.

In Example 6, the subject matter of Example 5 includes, wherein determining, using the processor, to divert at least a portion of the airflow to the air mattress includes determining that the information sensed by the sensor has traversed a threshold.

In Example 7, the subject matter of Examples 1-6 includes, wherein the circuitry includes a processor, the method further comprising: receiving an instruction, using the processor, to divert at least a portion of the airflow to a compression device; and sending an instruction, using the processor, to a flow management device to divert at least portion of the airflow to the compression device; and diverting, using the flow management device, at least a portion of the airflow to compression device.

In Example 8, the subject matter of Examples 1-7 includes, wherein the circuitry includes a processor, the method further comprising: sensing, using a sensor, information related to a compression device; receiving, using the processor, the information from the sensor; determining, using the processor and the information received from the sensor, to divert at least a portion of the airflow to the compression device; and sending an instruction; using the processor, to a flow management device to divert at least a portion of the airflow to the compression device.

In Example 9, the subject matter of Example 8 includes, wherein determining, using the processor, to divert at least a portion of the airflow to the air mattress includes determining that the information sensed by the sensor has traversed a threshold.

In Example 10, the subject matter of Examples 1-9 includes, sensing, using a sensor, a pressure in the specified channel, receiving, using the processor, the pressure; determining, using the processor, that the pressure has traversed a threshold, and if the pressure has traversed the threshold, adjusting, using the processor, an output of the fan.

In Example 11, the subject matter of Examples 1-10 includes, wherein the housing comprises a heat-resistant cowling.

Example 12 is at least one non-transitory machine-readable medium including instructions for vacuuming air in an operating room, which when executed by processing circuitry, cause the processing circuitry to perform operations comprising: receiving one or more instructions to provide power to a fan disposed in a surgical module, wherein the housing is configured to store unrelated electronic and electromechanical surgical equipment within the housing; providing power to the fan, wherein providing power to the fan causes air from a surgical field to be collected into a plenum through an inlet vent, and causes heat generated by the electronic surgical equipment to be collected into the plenum, wherein providing power to the fan causes the collected air and heat to create an airflow that passes through a specified channel in the housing, and wherein the controlled airflow causes the equipment stored in the module to be cooled and the airflow to be cleaned before being exhausted out of the housing through an outlet vent.

In Example 13, the subject matter of Example 12 includes, wherein the processing circuitry is further configured to perform operations to: receive the one or more instructions including an instruction to actuate a noise canceling device, wherein the noise canceling device is configured to cancel at least a portion of a noise generated by the fan.

In Example 14, the subject matter of Examples 12-13 includes, wherein the plenum substantially separates the air collected through the inlet vent from being in contact with the electronic and electromechanical equipment.

In Example 15, the subject matter of Examples 12-14 includes, wherein the processing circuitry is further configured to perform operations to: receive an instruction to divert at least a portion of the airflow to an air mattress; and send an instruction to a flow management device to divert at least portion of the airflow to the air mattress; and divert at least a portion of the airflow to the air mattress.

In Example 16, the subject matter of Examples 12-15 includes, wherein the processing circuitry is further configured to perform operations to: sense, using a sensor, information related to an air mattress; receive, using the processor, the information from the sensor; determine, using the processor and the information received from the sensor, to divert at least a portion of the airflow to the air mattress; and send an instruction; using the processor, to a flow management device to divert at least a portion of the airflow to the air mattress.

In Example 17, the subject matter of Example 16 includes, wherein determining to divert at least a portion of the airflow to the air mattress includes determining that the information sensed by the sensor has traversed a threshold.

In Example 18, the subject matter of Examples 12-17 includes, wherein the processing circuitry is further configured to perform operations to: receive an instruction to divert at least a portion of the airflow to a compression device; and send an instruction to a flow management device to divert at least portion of the airflow to the compression device; and divert, using the flow management device, at least a portion of the airflow to compression device.

In Example 19, the subject matter of Examples 12-18 includes, wherein the processing circuitry is further configured to perform operations to: sense, using a sensor, information related to a compression device; receive the information from the sensor; determine from the received information, to divert at least a portion of the airflow to the compression device; and send an instruction to a flow management device to divert at least a portion of the airflow to the compression device.

In Example 20, the subject matter of Example 19 includes, wherein determining to divert at least a portion of the airflow to the air mattress includes determining that the information sensed by the sensor has traversed a threshold.

In Example 21, the subject matter of Examples 12-20 includes, wherein the processing circuitry is further configured to perform operations to: sense using a sensor, pressure information related to a pressure in the specified channel, receive the pressure information; determine that the pressure has traversed a threshold, and if the pressure has traversed the threshold, adjust an output of the fan.

In Example 22, the subject matter of Examples 12-21 includes, wherein the housing comprises a heat-resistant cowling.

Example 23 is at least one machine-readable medium including instructions that, when executed by processing circuitry, cause the processing circuitry to perform operations to implement of any of Examples 1-22.

Example 24 is an apparatus comprising means to implement of any of Examples 1-22.

Example 25 is a system to implement of any of Examples 1-22.

Example 16 is a method to implement of any of Examples 1-12.

Example Set 2

Example 1 is a method of reducing germs in an operating room, the method comprising: determining, using a processor, to activate a disinfection system based on a disinfection time stored on a memory; and sending instructions, based on the disinfection time, to turn on the disinfection system, wherein the disinfection system is located at a top end portion of a housing having electronic and electro-mechanical medical equipment disposed therein.

In Example 2, the subject matter of Example 1 includes, wherein the disinfection system includes UV-C lights configured to shine outward and or downward from the top end portion of the housing, and wherein turning on the disinfection system includes turning on the UV-C lights.

In Example 3, the subject matter of Examples 1-2 includes, sending instructions based on the disinfection time, using the processor, to actuate an electro-mechanical mechanism configured to deploy the disinfection system, wherein when the electro-mechanical mechanism is actuated, the disinfection system is caused to move in a direction outward from the housing.

In Example 4, the subject matter of Example 3 includes, sending instructions based on an end disinfection time, using the processor, to actuate the electro-mechanical mechanism to retract the disinfection system, wherein when the electro-mechanical mechanism is retracted, the disinfection system is caused to move in a direction towards the housing.

In Example 5, the subject matter of Examples 1-4 includes, receiving from motion sensor, using the processor, information about motion in the medical setting around the housing and preventing actuation, or turning off the disinfection system if motion is sensed within a specified range.

In Example 6, the subject matter of Examples 1-5 includes, wherein sending instructions, based on the disinfection time, to turn on the disinfection system, includes turning on a second disinfection system located closer to a bottom end portion of the housing, wherein the bottom end portion is opposite the top end portion.

Example 7 is at least one non-transitory machine-readable medium including instructions for reducing germs in an operating room, which when executed by processing circuitry, cause the processing circuitry to perform operations comprising: activate a disinfection system, based on a disinfection time stored on a memory; and turn on the disinfection system, wherein the disinfection system is located at a top end portion of a housing having electronic and electro-mechanical medical equipment disposed therein.

In Example 8, the subject matter of Example 7 includes, wherein the disinfection system includes UV-C lights configured to shine outward and or downward from the top end portion of the housing, and wherein turning on the disinfection includes turning on the UV-C lights.

In Example 9, the subject matter of Examples 7-8 includes, sending instructions to actuate an electro-mechanical mechanism configured to deploy the disinfection system, based on the disinfection time, wherein when the electro-mechanical mechanism is actuated, the disinfection system is caused to move in a direction outward from the housing.

In Example 10, the subject matter of Example 9 includes, sending instructions to actuate the electro-mechanical mechanism to retract the disinfection system, based on an end disinfection time, wherein when the electro-mechanical mechanism is retracted, the disinfection system is caused to move in a direction towards the housing.

In Example 11, the subject matter of Examples 7-10 includes, receiving from a motion sensor, information about motion in the medical setting around the housing, and preventing actuation, or turning off the disinfection system if motion is sensed within a specified range.

In Example 12, the subject matter of Examples 7-11 includes, wherein sending instructions, based on the disinfection time, to turn on the disinfection system, includes turning on a second disinfection system located closer to a bottom end portion of the housing, wherein the bottom end portion is opposite the top end portion.

Example 13 is at least one machine-readable medium including instructions that, when executed by processing circuitry, cause the processing circuitry to perform operations to implement of any of Examples 1-12.

Example 14 is an apparatus comprising means to implement of any of Examples 1-12.

Example 15 is a system to implement of any of Examples 1-12.

Example 16 is a method to implement of any of Examples 1-12.

Example Set 3

Example 1 is a method of monitoring waste fluid during a surgery, the method comprising: receiving from a sensor, using a processor, information about an amount of a waste fluid collected in a waste fluid storage device, wherein the information includes, a first fluid amount measured at a first time and a second fluid amount measured at a second time; determining, using the processor, a delta between the first fluid amount and the second fluid amount, using the information; outputting the delta, using the processor, to display the delta on an electronic device, wherein the electronic device is coupled to a housing configured to store unrelated waste-heat producing electronic and electromechanical surgical equipment; and saving, using the processor, to a storage device having at least a portion of a patient's anesthetic record stored thereon, at least a portion of the information.

In Example 2, the subject matter of Example 1 includes, wherein the amount of waste fluid is a weight of the waste fluid.

In Example 3, the subject matter of Examples 1-2 includes, receiving from a second sensor, using the processor, information about a volume of blood in the waste fluid storage device; receiving from a third sensor, using the processor, information about a concentration of a blood characteristic in the waste fluid; receiving, from a memory, using the processor, information about a concentration of a blood characteristic in the patient prior to the surgery; determining an amount of blood in the waste fluid, using the processor, wherein determining the amount of blood in the waste fluid is determined by dividing the information about a concentration of a blood characteristic in the waste fluid by the information about a concentration of a blood characteristic in a patient prior to the surgery to establish a concentration ratio, and multiplying the concentration ratio by the information about a volume of blood in the waste fluid storage device; and outputting the amount of blood in the waste fluid, using the processor, to display the amount of blood in the waste fluid on the electronic device.

In Example 4, the subject matter of Example 3 includes, wherein the information about the volume of blood in the waste fluid storage device includes a correction to ignore a volume of foam in the waste fluid storage device.

In Example 5, the subject matter of Examples 3-4 includes, saving, to the storage device having at least a portion of a patient's anesthetic record stored thereon, the amount of blood in the waste fluid.

In Example 6, the subject matter of Examples 1-5 includes, wherein outputting the delta includes wirelessly sending the information to a tablet device in a surgical field.

In Example 7, the subject matter of Examples 1-6 includes, outputting, using the processor, an alert to a tablet device in a surgical field, the alert related to the amount of fluid or a measured level of fluid in the fluid storage device.

In Example 8, the subject matter of Examples 1-7 includes, wherein outputting the delta includes sending the information to a display mounted on a housing having a first surgical module and a second surgical module stored therein, wherein the first and second surgical modules include electrical and electro-mechanical surgical equipment, and wherein the first and second surgical modules support separate surgical functions.

In Example 9, the subject matter of Examples 1-8 includes, wherein saving at least a portion of the information includes determining an amount of blood in the waste fluid, and automatically saving information about the amount of blood in the waste fluid to the storage device having at least a portion of the patient's anesthetic record stored thereon.

In Example 10, the subject matter of Examples 1-9 includes, wherein the information includes a first fluid amount and a second fluid amount, and wherein determining the delta includes determining a rate of change between the first fluid amount measured at the first time and the second fluid amount measured at the second time, and outputting the rate of change, using the processor, to display the delta on the electronic device.

In Example 11, the subject matter of Examples 1-10 includes, activating, with the processor, a stirrer located proximate the fluid storage device to agitate and mix the waste fluid in the fluid storage device, wherein the stirrer is coupled to a housing including a substantially heat-confining cowling, the housing having a first surgical module and a second surgical module stored therein, wherein the first and second surgical modules include electrical and electro-mechanical surgical equipment, and wherein the first and second surgical modules support different surgical functions.

In Example 12, the subject matter of Examples 1-11 includes, activating, with the processor, a vacuum pump to induce a negative air pressure on an inside of a fluid suction bag disposed in the fluid storage device.

In Example 13, the subject matter of Examples 1-12 includes, determining, with the processor, that a level of fluid in the fluid storage device has traversed a threshold; and activating, with the processor, a vacuum valve to a to shift a flow of waste fluid from the fluid storage device to a second fluid storage device.

Example 14 is at least one non-transitory machine-readable medium including instructions for monitoring waste fluid during a surgery, which when executed by processing circuitry, cause the processing circuitry to perform operations comprising: receiving information about an amount of a waste fluid collected in a waste fluid storage device, from a sensor, wherein the information includes, a first fluid amount measured at a first time and a second fluid amount measured at a second time; determining, a delta between the first fluid amount and the second fluid amount, using the information; outputting the delta, to display the delta on an electronic device, wherein the electronic device is coupled to a housing configured to store unrelated waste-heat producing electronic and electromechanical surgical equipment; and saving at least a portion of the information, to a storage device having at least a portion of a patient's anesthetic record stored thereon.

In Example 15, the subject matter of Example 14 includes, wherein the amount of waste fluid is a weight of the waste fluid.

In Example 16, the subject matter of Examples 14-15 includes, the operations further comprising: receiving information about a volume of blood in the waste fluid storage device, from a second sensor; receiving information about a concentration of a blood characteristic in the waste fluid, from a third sensor; receiving information about a concentration of a blood characteristic in the patient prior to the surgery from a memory, using the processor; determining an amount of blood in the waste fluid, wherein determining the amount of blood in the waste fluid is determined by dividing the information about a concentration of a blood characteristic in the waste fluid by the information about a concentration of a blood characteristic in a patient prior to the surgery to establish a concentration ratio, and multiplying the concentration ratio by the information about a volume of blood in the waste fluid storage device; and outputting the amount of blood in the waste fluid, using the processor, to display the amount of blood in the waste fluid on the electronic device.

In Example 17, the subject matter of Example 16 includes, wherein the information about the volume of blood in the waste fluid storage device includes a correction to ignore a volume of foam in the waste fluid storage device.

In Example 18, the subject matter of Examples 16-17 includes, the operations further comprising: saving, to the storage device having at least a portion of a patient's anesthetic record stored thereon, the amount of blood in the waste fluid.

In Example 19, the subject matter of Examples 14-18 includes, wherein outputting the delta includes wirelessly sending the information to a tablet device in a surgical field.

In Example 20, the subject matter of Examples 14-19 includes, the operations further comprising: outputting, using the processor, an alert to a tablet device in a surgical field, the alert related to the amount of fluid or a measured level of fluid in the fluid storage device.

In Example 21, the subject matter of Examples 14-20 includes, wherein outputting the delta includes sending the information to a display mounted on a housing having a first surgical module and a second surgical module stored therein, wherein the first and second surgical modules include electrical and electro-mechanical surgical equipment, and wherein the first and second surgical modules support separate surgical functions.

In Example 22, the subject matter of Examples 14-21 includes, wherein saving at least a portion of the information includes determining an amount of blood in the waste fluid, and automatically saving information about the amount of blood in the waste fluid to the storage device having at least a portion of the patient's anesthetic record stored thereon.

In Example 23, the subject matter of Examples 14-22 includes, wherein the information includes a first fluid amount and a second fluid amount, and wherein determining the delta includes determining a rate of change between the first fluid amount measured at the first time and the second fluid amount measured at the second time, and outputting the rate of change, using the processor, to display the delta on the electronic device.

In Example 24, the subject matter of Examples 14-23 includes, the operations further comprising: sending instructions to activate a stirrer located proximate the fluid storage device to agitate and mix the waste fluid in the fluid storage device, wherein the stirrer is coupled to a housing including a substantially heat-confining cowling, the housing having a first surgical module and a second surgical module stored therein, wherein the first and second surgical modules include electrical and electro-mechanical surgical equipment, and wherein the first and second surgical modules support different surgical functions.

In Example 25, the subject matter of Examples 14-24 includes, the operations further comprising: sending instructions to activate a vacuum pump to induce a negative air pressure on an inside of a fluid suction bag disposed in the fluid storage device.

In Example 26, the subject matter of Examples 14-25 includes, the operations further comprising: determining, with the processor, that a level of fluid in the fluid storage device has traversed a threshold; and activating, with the processor, a vacuum valve to a to shift a flow of waste fluid from the fluid storage device to a second fluid storage device.

Example 27 is at least one machine-readable medium including instructions that, when executed by processing circuitry, cause the processing circuitry to perform operations to implement of any of Examples 1-26.

Example 28 is an apparatus comprising means to implement of any of Examples 1-26.

Example 29 is a system to implement of any of Examples 1-26.

Example 30 is a method to implement of any of Examples 1-26.

Example Set 4

Example 1 is a method comprising: receiving an instruction, using circuitry, to secure a surgical module to a floor; applying a vacuum to a suction cup, using the circuitry, wherein the vacuum is provided by a vacuum pump operably coupled to the suction cup, and wherein the suction cup is located under the surgical module, and wherein applying the vacuum to the suction cup causes the suction cup to create a suction coupling with the floor.

In Example 2, the subject matter of Example 1 includes, wherein the vacuum is a continuous vacuum.

In Example 3, the subject matter of Examples 1-2 includes, wherein the vacuum pump is disposed within a housing of the surgical module.

In Example 4, the subject matter of Examples 1-3 includes, wherein the vacuum pump is a hospital vacuum source.

In Example 5, the subject matter of Examples 1~4 includes, receiving, using the circuitry, an instruction to decouple the surgical module from the floor; and actuating, using the circuitry, a lifting element to release the vacuum applied to the suction cup to decouple the surgical module from the floor.

In Example 6, the subject matter of Examples 1-5 includes, receiving, using the circuitry, an instruction to apply a vacuum to a waste fluid storage device; and applying, using the circuitry, a vacuum to the waste fluid storage device, wherein the vacuum is provided by the vacuum pump.

Example 7 is at least one non-transitory machine-readable medium including instructions for securing a surgical module to a floor, which when executed by circuitry, cause the circuitry to perform operations comprising: receiving an instruction to secure a surgical module to a floor; applying a vacuum to a suction cup, wherein the vacuum is provided by a vacuum pump operably coupled to the suction cup, and wherein the suction cup is located under the surgical module, and wherein applying the vacuum to the suction cup causes the suction cup to create a suction coupling with the floor.

In Example 8, the subject matter of Examples 6-7 includes, wherein the vacuum is a continuous vacuum.

In Example 9, the subject matter of Examples 6-8 includes, wherein the vacuum pump is disposed within a housing of the surgical module.

In Example 10, the subject matter of Examples 6-9 includes, wherein the vacuum pump is a hospital vacuum source.

In Example 11, the subject matter of Examples 6-10 includes, wherein the circuitry further performs operations to: receive an instruction to decouple the surgical module from the floor; and actuate a lifting element to release the vacuum applied to the suction cup to decouple the surgical module from the floor.

In Example 12, the subject matter of Examples 6-11 includes, wherein the circuitry further performs operations to receive an instruction to apply a vacuum to a waste fluid storage device; and apply a vacuum to the waste fluid storage device, wherein the vacuum is provided by the vacuum pump.

Example 13 is at least one machine-readable medium including instructions that, when executed by processing circuitry, cause the processing circuitry to perform operations to implement of any of Examples 1-12.

Example 14 is an apparatus comprising means to implement of any of Examples 1-12.

Example 15 is a system to implement of any of Examples 1-12.

Example 16 is a method to implement of any of Examples 1-12.

Example Set 5

Example 1 is a method for measuring urine output from a catheterized patient, the method comprising: receiving from a sensor, using circuitry, information corresponding to at least a weight of urine collected in a urine bag at a first time and a second weight of urine collected in the urine bag at a second time, wherein the sensor is operably coupled to a urine bag hanger configured to receive the urine bag, and wherein the urine bag hanger is coupled to a housing; determining, using the circuitry and the information, a volume of urine that corresponds to the weight of urine collected between the first time and the second time; saving, using the circuitry, to a storage device having at least a portion of a patient's anesthetic record stored thereon, a volume of urine output collected in the urine bag between the first time and the second time.

In Example 2, the subject matter of Example 1 includes, wherein the sensor is an electronic scale sensor.

In Example 3, the subject matter of Examples 1-2 includes, wherein the circuitry includes a processor.

In Example 4, the subject matter of Examples 1-3 includes, determining, using the circuitry and the information, a delta or rate of urine collected between the first time and the second time, and outputting the delta or rate, using the circuitry, to display the delta or rate of urine collected on an electronic device, wherein the electronic device is coupled to a housing configured to store unrelated waste-heat producing electronic and electromechanical surgical equipment.

In Example 5, the subject matter of Examples 1~4 includes, sensing, with the sensor, when the urine bag is initially placed on the urine bag hanger; and zeroing the first weight, using the circuitry, when the sensor senses that the urine bag is initially placed on the urine bag hanger to establish a start point for measuring the collection of urine.

Example 6 is at least one non-transitory machine-readable medium including instructions for performing operations to measure urine output from a catheterized patient, the method comprising: receiving information corresponding to at least a weight of urine collected in a urine bag at a first time and a second weight of urine collected in the urine bag at a second time using a sensor, wherein the sensor is operably coupled to a urine bag hanger configured to receive the urine bag, and wherein the urine bag hanger is coupled to a housing; determining, using the information, a volume of urine that corresponds to the weight of urine collected between the first time and the second time; saving to a storage device having at least a portion of a patient's anesthetic record stored thereon, a volume of urine output collected in the urine bag between the first time and the second time.

In Example 7, the subject matter of Example 6 includes, wherein the sensor is an electronic scale sensor.

In Example 8, the subject matter of Examples 6-7 includes, wherein the circuitry includes a processor.

In Example 9, the subject matter of Examples 6-8 includes, the operations further comprising: determining, using the information, a delta or rate of urine collected between the first time and the second time, and outputting the delta or rate to display the delta or rate of urine collected on an electronic device, wherein the electronic device is coupled to a housing configured to store unrelated waste-heat producing electronic and electromechanical surgical equipment.

In Example 10, the subject matter of Examples 6-9 includes, the operations further comprising: sensing, with the sensor, when the urine bag is initially placed on the urine bag hanger; and zeroing the first weight when the sensor senses that the urine bag is initially placed on the urine bag hanger to establish a start point for measuring the collection of urine.

Example 11 is at least one machine-readable medium including instructions that, when executed by processing circuitry, cause the processing circuitry to perform operations to implement of any of Examples 1-10.

Example 12 is an apparatus comprising means to implement of any of Examples 1-10.

Example 13 is a system to implement of any of Examples 1-10.

Example 14 is a method to implement of any of Examples 1-10.

Example Set 6

Example 1 is a method comprising: receiving an instruction, using processing circuitry, to provide air to at least one of a surgical air mattress or a surgical body compression device; sending an instruction, using the processing circuitry, to an air pump, causing air to be provided to at least one of the surgical air mattress or the surgical body compression device, wherein the air pump is disposed within a housing, and wherein the housing is configured to house a first surgical module and a second surgical module comprising unrelated waste heat-producing electronic and electromechanical surgical equipment.

In Example 2, the subject matter of Example 1 includes, receiving an instruction, using the processing circuitry, to activate a fan disposed within the housing; actuating the fan, using the processing circuitry, wherein actuating the fan causes an airflow to be received into an inlet vent of the housing, the airflow to be passed through an air cleaning device, and the airflow along with waste heat produced by the electronic and electromechanical surgical equipment to be exhausted through an outlet vent.

In Example 3, the subject matter of Example 2 includes, receiving information from a sensor, using the processing circuitry, the information indicating a sensed condition of the surgical air mattress or the surgical body compression device; and determining, using the processing circuitry, if the sensed condition has traversed a threshold, and if the sensed condition has traversed the threshold, actuating, using the processing circuitry, a flow managing device to divert at least a portion of the airflow to the surgical air mattress or the surgical body compression device to supplement the air provided by the air pump, based on the information received from the sensor.

In Example 4, the subject matter of Examples 2-3 includes, receiving an instruction, using the processing circuitry, to activate a noise cancellation device configured to cancel at least a portion of a noise generated by the fan or the air pump.

Example 5 is at least one non-transitory machine-readable medium including instructions for supplying air to a surgical air mattress or a surgical body compression device, which when executed by processing circuitry, cause the processing circuitry to perform operations comprising: receive an instruction to provide air to at least one of a surgical air mattress or a surgical body compression device; send an instruction, using the processing circuitry, to an air pump, to provide air to at least one of the surgical air mattress or the surgical body compression device, wherein the air pump is disposed within a housing, and wherein the housing is configured to house a first surgical module and a second surgical module comprising unrelated waste heat-producing electronic and electromechanical surgical equipment.

In Example 6, the subject matter of Example 5 includes, wherein the instructions further cause the processing circuitry to: receive an instruction to activate a fan disposed within the housing; activate the fan based on the instruction to activate the fan, wherein activating the fan causes an airflow to be received into an inlet vent of the housing, the airflow to be passed through an air cleaning device, and the airflow along with waste heat produced by the electronic and electromechanical surgical equipment to be exhausted through an outlet vent.

In Example 7, the subject matter of Example 6 includes, wherein the instructions further cause the processing circuitry to: receive information from a sensor indicating a second sensed condition of the surgical air mattress or the surgical body compression device; and determine if the second sensed condition has traversed a threshold, and if the second sensed condition has traversed the threshold, actuating a flow managing device to divert at least a portion of the airflow to the surgical air mattress or the surgical body compression device to supplement the air provided by the air pump, based on the information received from the sensor.

In Example 8, the subject matter of Examples 6-7 includes, wherein the instructions further cause the processing circuitry to: receive an instruction to activate a noise cancellation device configured to cancel at least a portion of a noise generated by the fan or the air pump.

Example 9 is at least one machine-readable medium including instructions that, when executed by processing circuitry, cause the processing circuitry to perform operations to implement of any of Examples 1-8.

Example 10 is an apparatus comprising means to implement of any of Examples 1-8.

Example 11 is a system to implement of any of Examples 1-8.

Example 12 is a method to implement of any of Examples 1-8.

Example Set 7

Example 1 is a method for filtering air in a surgical field, the method comprising: providing or receiving, into a housing having a heat-resistant cowling, a first surgical module; providing or receiving, into the housing, a second surgical module, wherein the first surgical module and the second surgical module are unrelated waste heat-producing electronic and electromechanical surgical equipment; containing, substantially within the housing, the waste heat generated by the first surgical module and the second surgical module; receiving an instruction, using circuitry, to activate a fan disposed within the housing; actuating the fan, using the circuitry, to create an airflow; receiving the airflow through an inlet vent and into a plenum, wherein the plenum includes, a plenum wall separating the first surgical module and the second surgical module from the plenum; passing the airflow through a filter, to remove infectious particles generated during a surgery; blowing at least a portion of the airflow through a vent tube; and exhausting, through an outlet vent, at least a portion of the airflow and at least a portion of the waste heat.

In Example 2, the subject matter of Example 1 includes, wherein providing or receiving the first surgical module includes providing or receiving anesthesia monitoring equipment, and wherein providing or receiving the second surgical module includes providing or receiving electrosurgical grounding equipment, and wherein the first surgical module and the second surgical module are cooled by the airflow.

In Example 3, the subject matter of Examples 1-2 includes, wherein receiving the airflow includes collecting air from a specified location proximate a head of a patient during a surgery.

In Example 4, the subject matter of Examples 1-3 includes, positioning a vacuum hose proximate a head of a patient during a surgery, wherein the vacuum hose is operably couplable to the inlet vent, and wherein receiving the air includes receiving the air through the vacuum hose.

In Example 5, the subject matter of Examples 1~4 includes, positioning a vacuum hose between a patient and a surgeon, wherein the vacuum hose is operably couplable to the inlet vent, and wherein receiving the airflow includes receiving the airflow through the vacuum hose.

In Example 6, the subject matter of Examples 1-5 includes, positioning a vacuum hose proximate a patient and a surgeon, wherein the vacuum hose is operably couplable to the inlet vent, and wherein receiving the airflow includes receiving the airflow through the vacuum hose.

In Example 7, the subject matter of Examples 1-6 includes, operably coupling a vacuum hose to the inlet vent, and positioning the vacuum hose proximate a lateral side body of a patient to evacuate the air from a ventilation dead zone, and wherein receiving the airflow includes receiving the airflow through the vacuum hose.

In Example 8, the subject matter of Examples 1-7 includes, wherein exhausting the airflow includes exhausting the airflow through the outlet vent positioned at least four feet above a floor that the housing is positioned on.

In Example 9, the subject matter of Examples 1-8 includes, wherein receiving the airflow includes collecting air from a specified location between a height of a surgical table and a floor of the surgical field during a surgery, and exhausting the airflow includes exhausting the airflow at least four feet above a floor that the housing is positioned on.

In Example 10, the subject matter of Examples 1-9 includes, inches of a surgical table in a surgical field during a surgery.

In Example 11, the subject matter of Examples 1-10 includes, positioning, under an arm-board of a surgical table and adjacent an anesthesia screen, a lower bulbous portion of the housing.

In Example 12, the subject matter of Examples 1-11 includes, positioning, under an arm-board of a surgical table and adjacent an anesthesia screen, a lower bulbous portion of the housing; and positioning, adjacent an anesthesia screen, an upper tower-like portion of the housing, the upper tower-like portion including one or more displays.

In Example 13, the subject matter of Examples 1-12 includes, positioning, under an arm-board of a surgical table and adjacent an anesthesia screen, a lower bulbous portion of the housing; and positioning, adjacent an anesthesia screen, an upper tower-like portion of the housing; and receiving the first and second surgical modules into a lower bulbous portion of the housing.

Example 14 is at least one non-transitory machine-readable medium including instructions for filtering air within a surgical field, which when executed by circuitry, cause the circuitry to perform operations comprising: cause one or more power sources to provide power to a first surgical module stored in an insulated housing, the first surgical module being associated with a first surgical function, and the first surgical module producing a first waste heat; cause the one or more power sources to provide power to a second surgical module stored in the housing, the second surgical module associated with a second surgical function, and the second surgical module producing a second waste heat, wherein the first surgical module and second surgical module are directed to different surgical functions; and receive an instruction to activate a fan disposed in the housing; activate the fan, wherein actuating the fan causes air to be collected from a specified location and to deliver an airflow to the housing causing the airflow to pass through a filter to remove infectious particles associated with the surgical field, and to pass at least a portion of the airflow through a vent tube, and to exhaust at least a portion of the airflow and at least a portion of the first and second waste heat through an outlet vent.

In Example 15, the subject matter of Example 14 includes, wherein the circuitry further performs operations to: receive an instruction to activate a noise cancellation device configured to cancel at least a portion of a noise generated by the fan.

In Example 16, the subject matter of Examples 14-15 includes, wherein causing the one or more power sources to power the first surgical module includes powering an anesthesia monitor.

In Example 17, the subject matter of Examples 14-16 includes, wherein to cause the one or more power sources to power the second surgical module includes powering an electrosurgical generator.

In Example 18, the subject matter of Examples 14-17 includes, wherein to cause the one or more power sources to power the first and second surgical modules includes powering an anesthesia monitor and powering an electrosurgical generator.

In Example 19, the subject matter of Examples 14-18 includes, wherein to activate the fan includes activating the fan positioned and configured to collect the air from a specified location proximate a head of a patient during a surgery.

In Example 20, the subject matter of Examples 14-19 includes, wherein to activate the fan includes activating the fan positioned and configured to evacuate the air from a ventilation dead zone proximate a lateral side body of a patient.

In Example 21, the subject matter of Examples 14-20 includes, wherein to activate the fan includes activating a fan positioned and configured to exhaust at least a portion of the airflow at least four feet above a floor that the housing is positioned on.

In Example 22, the subject matter of Examples 14-21 includes, wherein to activate the fan causes air to be collected from a location at or below the height of the surgical table in a surgical field during a surgery, and wherein to exhaust the air from the housing, includes exhausting the air at least five feet above the floor that the housing is positioned on.

In Example 23, the subject matter of Example 22 includes, wherein to activate the fan causes air to be collected at a location between an underside of a surgical table and a floor that the surgical table is positioned above.

In Example 24, the subject matter of Examples 14-23 includes, wherein the housing substantially confines the waste heat produced by the first and second surgical modules.

Example 25 is at least one machine-readable medium including instructions that, when executed by processing circuitry, cause the processing circuitry to perform operations to implement of any of Examples 1-24.

Example 26 is an apparatus comprising means to implement of any of Examples 1-24.

Example 27 is a system to implement of any of Examples 1-24.

Example 28 is a method to implement of any of Examples 1-24.

Example Set 8

In an example 1, a module for housing unrelated electronic and electromechanical equipment for use during surgery including an ultraviolet operating room disinfection system, the module comprising:

- a lower section for housing unrelated electronic and electromechanical equipment;
- a tower-like upper section located on top of the lower section;
- the top of the tower-like upper section terminates at least 5 feet above the floor;
- a water-resistant cowling enclosing at least a portion of the lower section and the tower-like upper section; and
- a cartridge containing one or more ultraviolet-C producing lights that is protectively housed within the tower-like upper section;
- the cartridge containing one or more ultraviolet-C producing lights that emerges upward from the top of the tower-like upper section to substantially seat itself on the top of the tower-like upper section when activated;
- wherein the elevated location on top of the tower-like upper section allows the ultraviolet-C light to disinfect the patient and staff-contacting upper surfaces of the equipment in the operating room.

1a. The module of any preceding example, wherein the one or more ultraviolet-C producing lights in the cartridge containing the one or more ultraviolet-C producing lights are arranged to project ultraviolet-C light in the full 360o surrounding the module.

1b. The module of any preceding example, wherein one or more of the ultraviolet-C producing lights in the cartridge containing the one or more ultraviolet-C producing lights are oriented to shine on the module and thus disinfect it by pivoting to an angle that extends the one or more lights outward from the sides of the tower-like upper section when activated.

1c. The module of any preceding example, wherein at least four of the ultraviolet-C producing lights are oriented to shine on the module and thus disinfect it by pivoting to a partially horizontal angle that extends the four or more lights outward from the tower-like upper section when activated allowing them to shine directly on all sides of the module.

1d. The module of any preceding example, wherein at least four ultraviolet-C producing lights are mounted in the four corners of the lower section near the floor and are oriented to shine on the floor and undersides of the equipment in the operating room.

1e. The module of any preceding example, wherein the lower section has a bulbous form configured to allow that the rear portion of the tower-like upper section to be positioned adjacent the anesthesia side of one of the arm-boards of the surgical table with the bulbous lower section fitting into the unused space under the arm board.

In an example 2, a module for housing unrelated electronic and electromechanical equipment for use during surgery including a waste blood and fluid suction system, the module comprising:

- a lower section for housing unrelated electronic and electromechanical equipment;
- a tower-like upper section located on top of the lower section;
- a water-resistant cowling enclosing at least a portion of the lower section and the tower-like upper section; and
- one or more bucket-like recesses in or on the cowling of the lower section for mounting one or more fluid suction canisters;
- the fluid suction canisters mounted on the one or more bucket-like recesses are operably connected to a vacuum source controlled from within the module;

wherein the bucket-like recesses for mounting one or more fluid suction canisters also include one or more electronic scales for measuring the combined weight of each fluid suction canister and its blood and fluid contents.

2a. The module of any preceding example, wherein the one or more electronic scales for measuring the combined weight of each fluid suction canister and its blood and fluid contents allow an accurate calculation of the volume of the blood and fluid in the one or more canisters while omitting the false volume produced by air bubbles and foam.

2b. The module of any preceding example, wherein the bucket-like recesses for mounting one or more fluid suction canisters also include one or more optical or infrared fluid level sensors for sensing the combined volume of blood, fluid, air bubbles and foam in the canister.

2c. The module of any preceding example, wherein the optical or infrared fluid level sensors for sensing the combined volume of blood, fluid, air bubbles and foam in the one or more canisters are operably connected to the vacuum source controlled from within the module and can automatically stop the vacuum applied to any canister that that has been filled to its useful capacity.

2d. The module of any preceding example, wherein the bucket-like recesses for mounting one or more fluid suction canisters also include one or more optical or infrared sensors for determining the hematocrit of the blood and fluid in the canister.

2e. The module of any preceding example, wherein the output of the one or more optical or infrared sensors for determining the hematocrit of the blood and fluid in the canister plus the measurement of the volume of blood and fluid in the canister as determined by weight is inputted to a microprocessor in the module to calculate blood loss.

2f. The module of any preceding example, wherein the lower section has a bulbous form configured to allow that the rear portion of the tower-like upper section to be positioned adjacent the anesthesia side of one of the arm-boards of the surgical table with the bulbous lower section fitting into the unused space under the arm board.

In an example 3, a module for housing unrelated electronic and electromechanical equipment for use during surgery and providing a mounting location for equipment accessing the surgical field, the module comprising:

- a bulbous lower section for housing unrelated electronic and electromechanical equipment;
- at least a portion of the bulbous lower section fits into an unused space under the arm-board of a surgical table;
- a tower-like upper section located on top of the lower section;
- the tower-like upper section is taller than the height of the anesthesia screen;
- a water-resistant cowling enclosing at least a portion of the lower section and the tower-like upper section;
- wherein the tower-like upper section can be positioned adjacent the anesthesia side of an arm-board of a surgical table adjacent the anesthesia screen, and the rear side of the tower-like upper section that is facing the surgical field can be used for mounting various pieces of surgical equipment that need direct access to the surgical field from the head end.

3a. The module of any preceding example, wherein the upper portion of the tower-like upper section that is facing the surgical field can be used for mounting monitor screens such as patient vital sign monitor screens, surgical scope monitor screens, surgical check list monitor screens, safety check list monitor screens, communications and message monitor screens, clocks and timing device screens.

3b. The module of any preceding example, wherein the upper portion of the tower-like upper section that is facing the surgical field can be used for mounting surgical lights aiming at the surgical field.

3c. The module of any preceding example, wherein the upper portion of the tower-like upper section that is facing the surgical field can be used for mounting articulating arms that can "reach" across the upper edge of the anesthesia screen, into the sterile surgical field and hold surgical lights, surgical instruments, surgical scopes or surgical retractors.

3d. The module of any preceding example, wherein the upper portion of the tower-like upper section that is facing the surgical field can be used for mounting one or more video cameras for recording the surgical procedure.

3e. The module of any preceding example, wherein the upper portion of the tower-like upper section that is facing the surgical field can be used for mounting a sterile storage container for surgical supplies.

In an example 4, a module for housing unrelated electronic and electromechanical equipment for use during surgery including suction cups for anchoring the module to the floor, the module comprising:

- a lower section for housing unrelated electronic and electromechanical equipment;
- a tower-like upper section located on top of the lower section;
- a water-resistant cowling enclosing at least a portion of the lower section and the tower-like upper section; and
- one or more suction cups on the underside of the lower section that may be lowered to engage with the floor,
- wherein a suction anchor for stabilizing the module is created when the one or more suction cups are lowered to engage with the floor and a vacuum from a vacuum source controlled in the module is applied to the inside of the suction cups.

4a. The module of any preceding example, wherein the vacuum source is the hospital vacuum supplied to the module.

4b. The module of any preceding example, wherein the vacuum source is a vacuum pump housed within the module.

4c. The module of any preceding example, wherein the one or more suction cups are lowered by pneumatic cylinder actuators to engage with the floor.

4d. The module of any preceding example, wherein the one or more suction cups are lowered by electromechanical actuators to engage with the floor.

4e. The module of any preceding example, wherein the one or more suction cups are lowered by manual actuators to engage with the floor.

In an example 5, a surgical field ventilation optimization system powered by a waste air management system housed in a module, the surgical field ventilation optimization system comprising:

- one or more sterile hoses that are placed in the sterile surgical field with their distal ends located on top of the surgical drape substantially in the space between the surgical wound and the surgeon, where the ventilation flow boundary layer dead zone that naturally forms in front of the surgeon is located;
- the distal ends of the one or more hoses include one or more holes in the hoses that allow 5-50 CFM of airflow;
- the proximal ends of the one or more sterile hoses are attached to a vacuum source;
- wherein, a vacuum is applied to the proximal end of the one or more sterile hoses causing air to enter the distal

ends of the hoses evacuating and effectively deflating the flow boundary layer dead zone that naturally forms in front of the surgeon.

5a. The surgical field ventilation optimization system of any preceding example, wherein the vacuum source is a waste air management system housed in a module.

5b. The surgical field ventilation optimization system of any preceding example, wherein the vacuum source is a waste air management system housed in a module for housing unrelated electronic and electromechanical equipment during surgery.

5c. The surgical field ventilation optimization system of any preceding example, wherein the distal ends of the one or more hoses are adhesively attached to the sterile drape.

5d. The surgical field ventilation optimization system of any preceding example, wherein the proximal ends of the one or more hoses may be combined in order to reduce the number of hoses being attached to the vacuum source.

5e. The surgical field ventilation optimization system of any preceding example, wherein evacuating and deflating the flow boundary layer dead zone that naturally forms in front of the surgeon results in the ventilation airflow remaining unimpeded which keeps the airborne contaminating particles airborne, thus preventing them from settling into the open wound.

Example Set 9

Example 1 is a module for housing unrelated electronic and electromechanical surgical equipment including a system to measure and record administration of one or more IV medications or fluids for IV administration, the module comprising: a housing having a lower section and a tower-like upper section, wherein the lower section is configured to house unrelated waste heat-producing electronic and electromechanical surgical equipment, and wherein the tower-like upper section is located on top of the lower section, wherein the upper section is configured to accommodate mounting of equipment controls, display screens and monitor screens at a convenient height for viewing and operating; a cowling that substantially confines waste heat generated by the unrelated waste heat-producing electronic and electromechanical surgical equipment; and a system for measuring and recording the administration of the one or more IV medications and fluids, the system comprising: a barcode reader or an RFID interrogator configured to identify at least one of the one or more IV medications or fluids; and a machine vision digital camera in electrical communication with processing circuitry configured to determine a volume of medication administered from a syringe or fluid administered from an IV bag through an IV drip chamber into an IV tubing based on an image generated by the machine vision digital camera.

In Example 2, the subject matter of Example 1 includes, the system to measure and record the administration of the one or more IV medications or fluids further comprising: an injection portal; and one or more orienting members, wherein the injection portal includes an injection port that is configured to be in fluid communication with the IV tubing and the one or more orienting members are configured to guide syringes of varying diameters to mate with the injection port within the injection portal.

In Example 3, the subject matter of Example 2 includes, wherein the system to measure and record the administration of the one or more IV medications or fluids further comprises: a display in electrical communication with the machine vision digital camera, wherein the machine vision digital camera is configured to capture an image of a syringe when the syringe is inserted inside the injection portal, and wherein the display is configured to output a visual image or representation of the syringe.

In Example 4, the subject matter of Examples 2-3 includes, wherein the machine vision digital camera is located to capture an image of an inside of the injection portal, and wherein the processing circuitry is configured to interpret the image of a syringe when the syringe is inserted into the injection portal to measure the volume of medication injected from the syringe by determining a size and an internal diameter of the syringe and measuring a distance a plunger of the syringe moves to calculate an injected volume.

In Example 5, the subject matter of Examples 1-4 includes, wherein the RFID interrogator is configured to identify at least one of the one or more IV medications or fluids for IV administration that has been labeled with an RFID tag.

In Example 6, the subject matter of Examples 1-5 includes, wherein the machine vision digital camera that is in electrical communication with the processing circuitry is configured to read a barcode to identify a medication or fluid for IV administration that has been labeled with a barcode.

In Example 7, the subject matter of Examples 1-6 includes, wherein the system to measure and record the administration of the one or more IV medications or fluids further comprises: a display in electrical communication with the machine vision digital camera, wherein the display is configured to output medication and fluid identification and injection information including one or more of: a brand name of a drug, a generic name of a drug, a concentration of a drug, a dosage of a drug, a dosage delivered, a fluid flow rate, a fluid volume delivered, a patient allergy, an alert for over-dosing, an alert for a drug allergy and an alert for drug interactions on the display.

In Example 8, the subject matter of Example 7 includes, wherein the system to measure and record the administration of the one or more IV medications or fluids further comprises or is in electrical communication with one or more of: an electronic anesthetic record (EAR) and an electronic medical record (EMR), and wherein the system automatically records at least some of the administration of the one or more IV medications in one or both of the (EAR) and the (EMR).

In Example 9, the subject matter of Examples 2-8 includes, wherein the system to measure and record the administration of the one or more IV medications or fluids further comprises: a mechanical clamp configured to clamp the IV tubing, the mechanical clamp positioned upstream or downstream from the injection port, wherein the mechanical clamp can be automatically actuated to mechanically compress the IV tubing to stop the administration of the one or more IV medications or fluids when an adverse condition is determined by the processing circuitry.

In Example 10, the subject matter of Examples 2-9 includes, wherein the injection portal includes one or more UV lights that shine on the injection port.

In Example 11, the subject matter of Examples 1-10 includes, wherein the machine vision digital camera is located adjacent to the IV drip chamber, and wherein the processing circuitry is configured to interpret the image of drops in the IV drip chamber and determine a volume of fluid flowing from the IV bag by determining a size of drops and a number of drops per unit time to calculate a fluid flow rate.

In Example 12, the subject matter of Examples 1-11 includes, wherein the system to measure and record the administration of the one or more IV medications or fluids further comprises: a hanger configured to support an IV bag; and an electronic scale in electrical communication with a processor, wherein the electronic scale is configured to measure a combined weight of the IV bag, the IV drip chamber, the IV tubing and the fluids in the IV bag, and wherein the processor is configured to determine a reduction in the measured combined weight over time to determine the weight of the IV fluids infused over time and convert the measured combined weight over time to a fluid flow rate and an infused fluid volume.

In Example 13, the subject matter of Examples 1-12 includes, wherein the system to measure and record the administration of the one or more IV medications or fluids further comprises: a hanger configured to receive the IV bag; an electronic scale in electrical communication with a processor, wherein the hanger is configured to support the IV bag; and a float located in the IV drip chamber, wherein the machine vision digital camera is located adjacent to the IV drip chamber, and wherein the processing circuitry is configured to determine a volume of fluid flowing from the IV bag by determining a size of drops and a number of the drops per unit time to calculate a fluid flow rate, wherein the electronic scale is configured to measure a combined weight of the IV bag, the IV drip chamber, the IV tubing and the fluid in the IV bag, and wherein the processing circuitry is configured to determine a reduction in the measured combined weight over time to determine a weight of the IV fluids infused over time and convert the measured combined weight over time to a fluid flow rate and infused fluid volume, wherein at higher flow rates, when the drops in the IV drip chamber coalesce into a fluid stream that is uninterpretable by the machine vision camera and processing circuitry, the fluid stream causes a float in the IV drip chamber to move indicating that fluid is flowing, and wherein when the system fails to identify individual drops and detects that the float is moving, the processing circuitry is configured to measure a fluid flow rate by determining a reduction of the combined weight of the IV bag, the IV drip chamber, the IV tubing and the fluid in the IV bag over time.

In Example 14, the subject matter of Examples 1-13 includes, wherein the system to measure and record the administration of the one or more IV medications or fluids further comprises: one or more electro-mechanical clamps in electrical communication with the processing circuitry, wherein the machine vision digital camera is located adjacent the IV drip chamber that is configured to be connected to the IV bag, wherein the processing circuitry is configured to interpret the image including a fluid meniscus level in the IV drip chamber, and wherein when the fluid meniscus is not present, the processing circuitry causes actuation of the one or more electro-mechanical clamps to compress the IV tubing to stop a portion of an IV infusion before air can enter the IV tubing.

Example 15 is a module for housing unrelated electronic and electromechanical surgical equipment including a system to measure and record administration of one or more IV medications or fluids for IV administration to a patient, the module comprising: a housing having a lower section and a tower-like upper section, wherein the lower section is configured to house unrelated waste heat-producing electronic and electromechanical surgical equipment, and wherein the tower-like upper section is located on top of the lower section, wherein the upper section is configured to accommodate mounting of equipment controls, display screens and monitor screens at a convenient height for viewing and operating; a cable and hose management system located on a patient side of the module, wherein the patient side of the module is configured to face a patient and provide the closest and most direct access to the patient when the module is positioned adjacent an anesthesia side of an arm-board of a surgical table; and a system to measure and record the administration of the one or more IV medications and fluids, the system comprising: a barcode reader or an RFID interrogator configured to identify at least one of the one or more IV medications or fluids; and a machine vision digital camera in electrical communication with processing circuitry configured to determine a volume of medication administered from a syringe or fluid administered from an IV bag through an IV drip chamber into an IV tubing based on an image generated by the machine vision digital camera.

In Example 16, the subject matter of Example 15 includes, wherein the system to measure and record the administration of the one or more IV medications or fluids further comprises: an injection portal; and one or more orienting members, wherein the injection portal includes an injection port that is configured to be in fluid communication with the IV tubing and the one or more orienting members are configured to guide syringes of varying diameters to mate with the injection port within the injection portal.

In Example 17, the subject matter of Example 16 includes, wherein the system to measure and record the administration of the one or more IV medications or fluids further comprises: a display in electrical communication with the machine vision digital camera, wherein the machine vision digital camera is configured to capture an image of the syringe when the syringe is inserted inside the injection portal, and wherein the display is configured to output a visual image or representation of the syringe.

In Example 18, the subject matter of Examples 16-17 includes, wherein the machine vision digital camera is located to capture an image of an inside of the injection portal, and wherein the processing circuitry is configured to interpret the image of the syringe when the syringe is inserted into the injection portal to measure the volume of medication injected from the syringe by determining a size and an internal diameter of the syringe and measuring a distance a plunger of the syringe moves to calculate an injected volume.

In Example 19, the subject matter of Examples 15-18 includes, wherein the RFID interrogator is configured to identify at least one of the one or more IV medications or fluids for IV administration that has been labeled with an RFID tag.

In Example 20, the subject matter of Examples 15-19 includes, wherein the machine vision digital camera is in electrical communication with the processing circuitry is configured to read a barcode to identify a medication or fluid for IV administration that has been labeled with a barcode.

In Example 21, the subject matter of Examples 15-20 includes, wherein the system to measure and record the administration of the one or more IV medications or fluids further comprises: a display in electrical communication with the machine vision digital camera, wherein the display is configured to output medication and fluid identification and injection information including one or more of: a brand name of a drug, a generic name of a drug, a concentration of a drug, a dosage of a drug, a dosage delivered, a fluid flow rate, a fluid volume delivered, a patient allergy, an alert for over-dosing, an alert for a drug allergy and an alert for drug interactions on the display.

In Example 22, the subject matter of Example 21 includes, wherein the system to measure and record the administration of the one or more IV medications or fluids further comprises or is in electrical communication with one or more of: an electronic anesthetic record (EAR) and an electronic medical record (EMR), and wherein the system automatically records at least some of the administration of the one or more IV medications in one or both of the (EAR) and the (EMR).

In Example 23, the subject matter of Examples 16-22 includes, wherein the injection portal includes one or more UV lights that shine on the injection port.

In Example 24, the subject matter of Examples 15-23 includes, wherein the machine vision digital camera is located adjacent to the IV drip chamber, and wherein the processing circuitry is configured to interpret the image of drops in the IV drip chamber and determine a volume of fluid flowing from the IV bag by determining a size of drops and a number of drops per unit time to calculate a fluid flow rate.

In Example 25, the subject matter of Examples 15-24 includes, wherein the system to measure and record the administration of the one or more IV medications or fluids further comprises: a hanger configured to support an IV bag; and an electronic scale in electrical communication with a processor, wherein the electronic scale is configured to measure a combined weight of the IV bag, the IV drip chamber, the IV tubing and the fluids in the IV bag, and wherein the processor is configured to determine a reduction in the measured combined weight over time to determine the weight of the IV fluids infused over time and convert the measured combined weight over time to a fluid flow rate and an infused fluid volume.

Example 26 is a module comprising: a housing having a lower section and a tower-like upper section, wherein the lower section is configured to house unrelated waste heat-producing electronic and electromechanical surgical equipment, and wherein the tower-like upper section is located on top of the lower section; a cowling that substantially confines waste heat generated by the unrelated waste heat-producing electronic and electromechanical surgical equipment; a system for monitoring the administration of one or more IV medications and fluids, the system comprising: a barcode reader or an RFID interrogator configured to identify the one or more IV medications or fluids; a machine vision digital camera to capture an image of one or more of a syringe or a drip chamber; processing circuitry operably coupled to the barcode reader or the RFID interrogator to receive the identity of the one or more IV medications or fluids, the processing circuitry operably coupled to the machine vision digital camera to receive the captured image and determine a volume of medication administered from the syringe or fluid administered from an IV bag based on the image; and a display operably coupled to the processing circuitry, the display configured to receive instructions from the processing circuitry to output the identity and determined volume of medication administered from the syringe or fluid administered from an IV bag.

Example 27 is at least one machine-readable medium including instructions that, when executed by processing circuitry, cause the processing circuitry to perform operations to implement of any of Examples 1-26.

Example 28 is an apparatus comprising means to implement of any of Examples 1-26.

Example 29 is a system to implement of any of Examples 1-26.

Example 30 is a method to implement of any of Examples 1-26.

What is claimed is:

1. A module for housing electronic and electromechanical medical equipment including at least one machine vision digital camera, the module comprising:

a housing configured to house the electronic and electromechanical medical equipment;

a cowling that at least partially confines the electronic and electromechanical medical equipment; and

at least one machine vision digital cameras in electrical communication with processing circuitry and software, the processing circuitry and software configured to document healthcare events based on images generated by the at least one machine vision digital camera;

wherein each of the at least one machine vision digital cameras is mounted in a fixed position relative to a medical equipment item or a patient that is being observed by the at least one machine vision digital camera, thereby creating a structured scene based on the images, for the processing circuitry and software to analyze;

wherein the processing circuitry and software is programmed or taught where germane areas are located within the structured scene and wherein the processing circuitry and software is programmed or taught to focus image identification on the germane areas; and

wherein at least one machine vision digital camera is locatable to document delivery of IV fluids by counting drops in an IV fluid drip chamber wherein the structured scene is a lower portion of a bag of IV fluids including the IV fluid drip chamber and tubing, and wherein the germane areas of the structured scene includes the IV fluid drip chamber.

2. The module of claim **1**, wherein focusing image identification efforts on the germane areas of the structured scene increases image identification speed.

3. The module of claim **1**, wherein focusing image identification on the germane areas of the structured scene increases image identification accuracy and reliability.

4. The module of claim **1**, wherein at least one machine vision digital camera is locatable to document delivery of IV medication from a syringe by measuring a distance of movement of a plunger of the syringe, wherein the structured scene includes an inside of an injection portal including an inserted medication syringe, and wherein the germane areas of the structured scene includes a syringe barrel.

5. The module of claim **1**, wherein at least one machine vision digital camera is locatable to document delivery of inhaled anesthetics from an anesthetic vaporizer by measuring a position of a vaporizer dial of the anesthetic vaporizer, wherein the structured scene includes an image of a worktop area of an anesthesia machine including the anesthetic vaporizer, and wherein the germane areas of the structured scene includes the vaporizer dial.

6. The module of claim **1**, wherein at least one machine vision digital camera is locatable to document delivery of inhaled gases by measuring a height of one or more floats in a tube ventilation gas flow meter, wherein the structured scene includes an image of a control panel of an anesthesia machine including the tube ventilation gas flow meter, controls, and control display screens, and wherein the germane areas of the structured scene includes the tube ventilation gas flow meter.

7. The module of claim **1**, wherein at least one machine vision digital camera is locatable to document activities in a surgical field and a surgical procedure, wherein the structured scene includes an image of an entirety of the surgical field including a surgeon and assistants, and wherein the germane areas of the structured scene includes the surgical field.

8. The module of claim **1**, wherein at least one machine vision digital camera is locatable above a head of a patient in a supine position to document a face of the patient including skin color, lacrimation, sweating, coughing, salivating, grimacing, or other expressions, wherein the structured scene includes an image of a face, a pillow, a bed, a floor, and a surrounding area, and wherein the germane areas of the structured scene includes the face of the patient.

9. The module of claim **1**, wherein at least one machine vision digital camera is locatable to observe a patient to document at least one characteristic of a patient including skin color, lacrimation, sweating, coughing, salivating, grimacing, expressions, movement, getting out of bed, or breathing, and wherein the structured scene includes an image of the patient, a pillow, a bed, a floor and a surrounding area, and wherein the germane areas of the structured scene includes the patient.

10. The module of claim **1**, wherein the at least one machine vision digital camera is configured for wired or wireless electrical communication with processing circuitry and software.

11. The module of claim **1**, wherein the at least one machine vision digital camera is configured to provide images to the processing circuitry and software in intermittent timer intervals or in a continuous stream.

12. A module for housing electronic and electromechanical medical equipment including at least one machine vision digital camera, the module comprising:

a housing configured to house the electronic and electromechanical medical equipment;

a cable, hose, and IV tubing management system located on a patient side of the module, the module configured to face a patient during a procedure;

at least one machine vision digital camera configured to generate images, each of the at least one machine vision digital camera configured to be mounted in a fixed position relative to a medical equipment item or the patient that is being observed by the at least one machine vision digital camera, thereby creating a structured scene of images; and

processing circuitry and software configured to document healthcare events based on the images received from the at least one machine vision digital camera and based on the structured scene;

wherein the processing circuitry and software is programmed or taught where a germane area is located within the structured scene, and wherein the processing circuitry and software is programmed to focus image identification on the germane area; and

wherein at least one machine vision digital camera is positionable to generate gas images, wherein the processing circuitry and software is programmed to document delivery of inhaled gases by measuring a height of one or more floats in a tube ventilation gas flow meter using the gas images, wherein the structured scene includes an image of a control panel of an anesthesia machine including the tube ventilation gas flow meter, knobs, and control display screens, and wherein the germane area of the structured scene includes the tube ventilation gas flow meter.

13. The module of claim **12**, wherein focusing image identification efforts on the germane area of the structured scene increases identification speed.

14. The module of claim **12**, wherein the processing circuitry and software is programmed to focus identification on the germane area of the structured scene to increase identification accuracy and reliability.

15. The module of claim **12**, wherein the at least one machine vision digital camera is positionable to generate delivery images of delivery of IV medication from a syringe, wherein the processing circuitry and software is programmed to document the delivery by determining a distance of movement of a plunger of the syringe based on the delivery images, wherein the structured scene includes an inside of an injection portal including an inserted medication syringe, and wherein the germane area of the structured scene includes a syringe barrel.

16. The module of claim **12**, wherein at least one machine vision digital camera is positionable to generate fluid images of IV fluids, wherein the processing circuitry and software is programmed to document delivery by counting drops in an IV fluid drip chamber using the fluid images, wherein the structured scene is a lower portion of a bag of IV fluids including the IV fluid drip chamber and tubing, and wherein the germane area of the structured scene include the IV fluid drip chamber.

17. The module of claim **12**, wherein the at least one machine vision digital camera is positionable to generate anesthetics images of inhaled anesthetics from an anesthetic vaporizer, wherein the processing circuitry and software is programmed to document delivery by measuring a position of a vaporizer dial of the anesthetic vaporizer using the anesthetics images, wherein the structured scene includes an image of a worktop area of an anesthesia machine including the anesthetic vaporizer, and wherein the germane area of the structured scene includes the vaporizer dial.

18. The module of claim **12**, wherein at least one machine vision digital camera is positionable to generate procedure images, wherein the processing circuitry and software is programmed to document activities in a surgical field and a surgical procedure using the procedure images, wherein the structured scene includes an image of an entirety of the surgical field including a surgeon and assistants, and wherein the germane area of the structured scene includes the surgical field.

19. The module of claim **12**, wherein at least one machine vision digital camera is positionable above a head of a patient in a supine position to generate patient images, wherein the processing circuitry and software is programmed to document a face of the patient including skin color, lacrimation, sweating, coughing, salivating, grimacing, or other expressions using the patient images, wherein the structured scene includes an image of a face, a pillow, a bed, a floor, and a surrounding area, and wherein the germane area of the structured scene includes the face of the patient.

20. The module of claim **12**, wherein at least one machine vision digital camera is positionable to generate patient images, wherein the processing circuitry and software is programmed to observe a patient to document at least one characteristic of a patient including skin color, lacrimation, sweating, coughing, salivating, grimacing, expressions, movement, getting out of bed, or breathing using the patient images, and wherein the structured scene includes an image of the patient, a pillow, a abed, floor and a surrounding area, and wherein the germane area of the structured scene includes the patient.

21. The module of claim **12**, wherein the at least one machine vision digital camera is in wired or wireless electrical communication with processing circuitry and software.

22. The module of claim **12**, wherein the at least one machine vision digital camera is configured to generate and transmit images to the processing circuitry and software in intervals or in a continuous stream.

23. A module for housing electronic and electromechanical medical equipment including

at least one machine vision digital camera, the module comprising:

a housing configured to house the electronic and electromechanical medical equipment;

a cowling that at least partially confines the electronic and electromechanical medical equipment; and

at least one machine vision digital cameras in electrical communication with processing circuitry and software, the processing circuitry and software configured to document healthcare events based on images generated by the at least one machine vision digital camera;

wherein each of the at least one machine vision digital cameras is mounted in a fixed position relative to a medical equipment item or a patient that is being observed by the at least one machine vision digital camera, thereby creating a structured scene based on the images, for the processing circuitry and software to analyze;

wherein the processing circuitry and software is programmed or taught where germane areas are located within the structured scene and wherein the processing circuitry and software is programmed or taught to focus image identification on the germane areas; and

wherein at least one machine vision digital camera is locatable to document delivery of inhaled anesthetics from an anesthetic vaporizer by measuring a position of a vaporizer dial of the anesthetic vaporizer, wherein the structured scene includes an image of a worktop area of an anesthesia machine including the anesthetic vaporizer, and wherein the germane areas of the structured scene includes the vaporizer dial.

24. The module of claim **23**, wherein focusing image identification efforts on the germane areas of the structured scene increases image identification speed.

25. The module of claim **23**, wherein focusing image identification on the germane areas of the structured scene increases image identification accuracy and reliability.

26. The module of claim **23**, wherein at least one machine vision digital camera is locatable to document delivery of IV medication from a syringe by measuring a distance of movement of a plunger of the syringe, wherein the structured scene includes an inside of an injection portal including an inserted medication syringe, and wherein the germane areas of the structured scene includes a syringe barrel.

27. The module of claim **23**, wherein at least one machine vision digital camera is locatable to document delivery of inhaled anesthetics from an anesthetic vaporizer by measuring a position of a vaporizer dial of the anesthetic vaporizer, wherein the structured scene includes an image of a worktop area of an anesthesia machine including the anesthetic vaporizer, and wherein the germane areas of the structured scene includes the vaporizer dial.

* * * * *